

**Continued Operation of a 25-Raingage Network for
Collection, Reduction, and Analysis of Precipitation Data for
Lake Michigan Diversion Accounting: Water Year 2018**

Erin Bauer

July 2019



Illinois State Water Survey

PRAIRIE RESEARCH INSTITUTE

CONTINUED OPERATION OF A 25-RAINGAGE NETWORK
FOR COLLECTION, REDUCTION, AND ANALYSIS OF PRECIPITATION DATA
FOR LAKE MICHIGAN DIVERSION ACCOUNTING:
WATER YEAR 2018

REPORT

To

U.S. Army Corps of Engineers, Chicago District

Contract W912P6-08-C-0029

Erin Bauer
Project Analysis and Reporting

Jim Angel and David Kristovich
Principal Investigators

Illinois State Water Survey
Prairie Research Institute
University of Illinois
2204 Griffith Drive
Champaign, Illinois 61820-7495

July 2019

ABSTRACT

A dense raingage network has operated in Cook County since the fall of 1989 to provide accurate precipitation measurements for use in simulating runoff for Lake Michigan diversion accounting. This report describes the network design, operations and maintenance procedures, data reduction and quality control methodology, and an analysis of precipitation for WY2018 (October 2017–September 2018). The data analyses include: 1) monthly and annual WY2018 precipitation amounts at all 25 raingage sites, 2) WY2018 precipitation amounts compared to the previous 28-year network average pattern (WYs 1990–2017), and 3) the 29-year network precipitation average for WYs 1990–2018. Also included are raingage site descriptions, instructions for raingage technicians, and documentation of raingage maintenance and high storm totals.

CONTENTS	PAGE
1. INTRODUCTION	1
2. NETWORK DESIGN	1
3. NETWORK OPERATION AND MAINTENANCE	2
4. DATA COLLECTION AND REDUCTION	4
Precipitation Data Review and Final Data Array	4
5. DATA ANALYSIS FOR WATER YEAR 2018	5
Heavy Precipitation Event Recurrence	11
Twenty-Nine Year Average Precipitation Distribution	15
6. SUMMARY	17
7. ACKNOWLEDGMENTS	17
8. REFERENCES	18
APPENDIX I: LAKE MICHIGAN DIVERSION ACCOUNTING METHOD AND PRE- 1990 PRECIPITATION NETWORK	23
APPENDIX II: NETWORK DESIGN METHODOLOGY	27
APPENDIX III: RAINGAGE SITE DESCRIPTIONS	29
Explanation of WY2018 Gage Relocations	29
APPENDIX V: HISTORICAL NETWORK OPERATION AND MAINTENANCE	45
First Generation Raingages 1989 through 2001	45
Second Generation Raingages 2001 through 2010	46
Third Generation Raingages 2010 through 2018	46
APPENDIX IV: ISOHYETAL MAPS OF ANNUAL PRECIPITATION FOR WYS 1990– 2017	48
APPENDIX VI: INSTRUCTIONS FOR RAINGAGE TECHNICIANS	48

APPENDIX VII: DOCUMENTATION OF RAINGAGE MAINTENANCE	50
SITE 1: NORTHBROOK: MISSION BROOK SANITARY DISTRICT	51
SITE 2: WINNETKA: WINNETKA PARK DISTRICT	53
SITE 3: DES PLAINES: PRIVATE	54
SITE 4: VILLAGE OF SKOKIE: PRIVATE / TALKING FARM	55
SITE 5: FRANKLIN PARK: PRIVATE	57
SITE 6: CHICAGO: PRECISION DIALOGUE DIRECT	58
SITE 7: CHICAGO: BROADWAY UNITED METHODIST CHURCH / GRACELAND CEMETERY AND ARBORETUM.....	59
SITE 8: WESTCHESTER: FOREST PRESERVE.....	61
SITE 9: CICERO: WATER STATION.....	62
SITE 10: CHICAGO: CHICAGO SCENIC STUDIOS.	64
SITE 11: LA GRANGE: EDGEWOOD VALLEY COUNTRY CLUB.....	65
SITE 12: BEDFORD PARK: HALLSTAR	67
SITE 13: CHICAGO: GREUNE COAL COMPANY / POLICE DEPT.....	68
SITE 14: CHICAGO: SOUTH WATER PURIFICATION PLANT	69
SITE 15: LEMONT: SAINT MARY'S SEMINARY	70
SITE 16: PALOS PARK: PRIVATE / SWALLOW CLIFF STAIRS FOREST PRESERVE.	71
SITE 17: ALSIP: FIRE DEPARTMENT STATION #2.....	73
SITE 18: CHICAGO: AXLE TECH INTERNATIONAL.....	74
SITE 19: CHICAGO: GALLO EQUIPMENT	75
SITE 20: ORLAND PARK: PANDUIT CORPORATION	77
SITE 21: TINLEY PARK: PRIVATE	78
SITE 22: HARVEY: ARMY RESERVE BUILDING / WHIMSY INTERMODAL (same location, new landowner)	79
SITE 23: LANSING: POLICE DEPARTMENT.....	81
SITE 24: MATTESON: POLICE DEPARTMENT	82
SITE 25: CHICAGO HEIGHTS: BIG JOHN'S FARM STAND	84
APPENDIX VIII: DOCUMENTATION OF HIGH STORM TOTALS	94

TABLE OF FIGURES

Figure 1. The Cook County 25-site raingage network for WY2018	3
Figure 2. WY2018 monthly precipitation isohyets.....	7
Figure 3. Precipitation isohyets (inches) for WY2018 (Oct. 2017–Sept. 2018).....	10
Figure 4. WY2018 monthly network precipitation compared to the previous 28-year monthly average network precipitation	14
Figure 5. The 29-year average precipitation pattern (inches), WYs 1990–2018	16
Figure AI-1. Raingage locations used for diversion accounting purposes prior to WY1990	26
Figure AVII-1. Precipitation isohyets (inches) for WYs 1990–2017.....	86
Figure AVIII-1. The four most intense storm events during WYs 2008–2018.....	94

**CONTINUED OPERATION OF A 25-RAINGAGE NETWORK
FOR COLLECTION, REDUCTION, AND ANALYSIS OF PRECIPITATION DATA
FOR LAKE MICHIGAN DIVERSION ACCOUNTING:
WATER YEAR 2018**

by

Erin Bauer

1. INTRODUCTION

The volume of water diverted from Lake Michigan into the state of Illinois is monitored to ensure that the diversion does not exceed a long-term average of 3,200 cubic feet per second (cfs) as imposed by a 1967 U.S. Supreme Court Order, last updated in 1980. This diversion has a long history, dating back to the mid-1800s with the completion of the Illinois and Michigan Canal. Over the years, the diversion has been affected by such events as the flow reversal of the Chicago River and completion of the Chicago Sanitary and Ship Canal in 1900 and has weathered various legal proceedings that attempted to ensure that the diversion could be monitored and did not exceed certain limits. A key component of the monitoring procedure, administered by the U.S. Army Corps of Engineers (USACE), Chicago District, is the accurate representation of the precipitation that falls over portions of Cook County, Illinois.

This report describes and presents the precipitation component of the diversion monitoring, including the maintenance and operation of the Cook County precipitation network, the data reduction and analysis techniques employed, monthly gage precipitation totals, and a brief data analysis for WY2018, the 29th year of network operation.

Components and methods used for Lake Michigan Diversion Accounting and the history and explanation of the pre-1990 precipitation network can be found in Appendix I.

2. NETWORK DESIGN

The Illinois State Water Survey (ISWS) established and has operated the current 25-gage Cook County precipitation network since September 1989. The gages are distributed across Cook County on a 5- to 7-mile grid. Each gage is secured to the ground with its base approximately 8 inches above ground level and the top of its orifice at about 4 feet.

History and background of the precipitation gage network design and associated research are available in Appendix II.

Over the years, some of the gages have been relocated. Re-siting a gage within the highly urbanized areas of Chicago is challenging. New gage locations are researched using satellite imagery to identify and measure distances to possible obstructions. After a selection of alternate sites are chosen, the landowners are contacted and the sites are visited to confirm their appropriateness. With careful consideration, every effort is taken

to find a new location close to the original grid location, maintaining the 5- to 7-mile grid spacing between gages.

During WY2018, the gages for sites #4, #7, #10, #13, and #16 were moved. All locations of the precipitation gages for WY2018 (October 2017–September 2018) are shown in Figure 1. A site survey was performed at both the old and new sites when the gages were moved. Site surveys were also completed during this water year for sites #1, #2, #5, #8, #9, #14, and #15.

Since the network began collecting data in October 1989, 11 gages were relocated more than 0.25 miles, 9 gages were moved slightly (< 0.25 miles), and 5 sites have not been moved in the entire 29 years. Appendix III: Raingage Descriptions contains the site descriptions for each network gage location during WY2018.

3. NETWORK OPERATION AND MAINTENANCE

Since 2010, the refurbished weighing-bucket Belfort gages have been operated with Campbell Scientific Inc. CR200 data loggers and cell modems. The equipment is powered by a 12-volt battery and solar panel. The precipitation data are uploaded every hour to an ISWS computer. The most recent three days of 10-minute data and two weeks of hourly data are online at

<http://www.isws.illinois.edu/data/ccprecipnet/livedata.asp>. An explanation of network equipment, operation, and maintenance from 1989 through 2018 is provided in Appendix IV.

From the ISWS Champaign office, a technician reviews the downloaded data on a regular basis to check the status of each gage, logger, and battery. Maintenance visits to gages occur when either the collection buckets are nearly full, batteries need to be replaced, a gage appears to malfunction, or we are informed of vandalism by the gage site property owners or managers, and for twice-yearly servicing that includes calibration and either adding or removing antifreeze. At the beginning of the cold season (November–March), a 1-liter charge of antifreeze with an anti-evaporation suppressant is added to each bucket. Antifreeze causes frozen precipitation to melt in the bucket as it is caught, allowing the weighing mechanism to give a proper reading. Appendix V contains the complete set of servicing instructions for raingage technicians. Appendix VI provides a complete maintenance and repair history of the raingage network conducted through September 30, 2018.

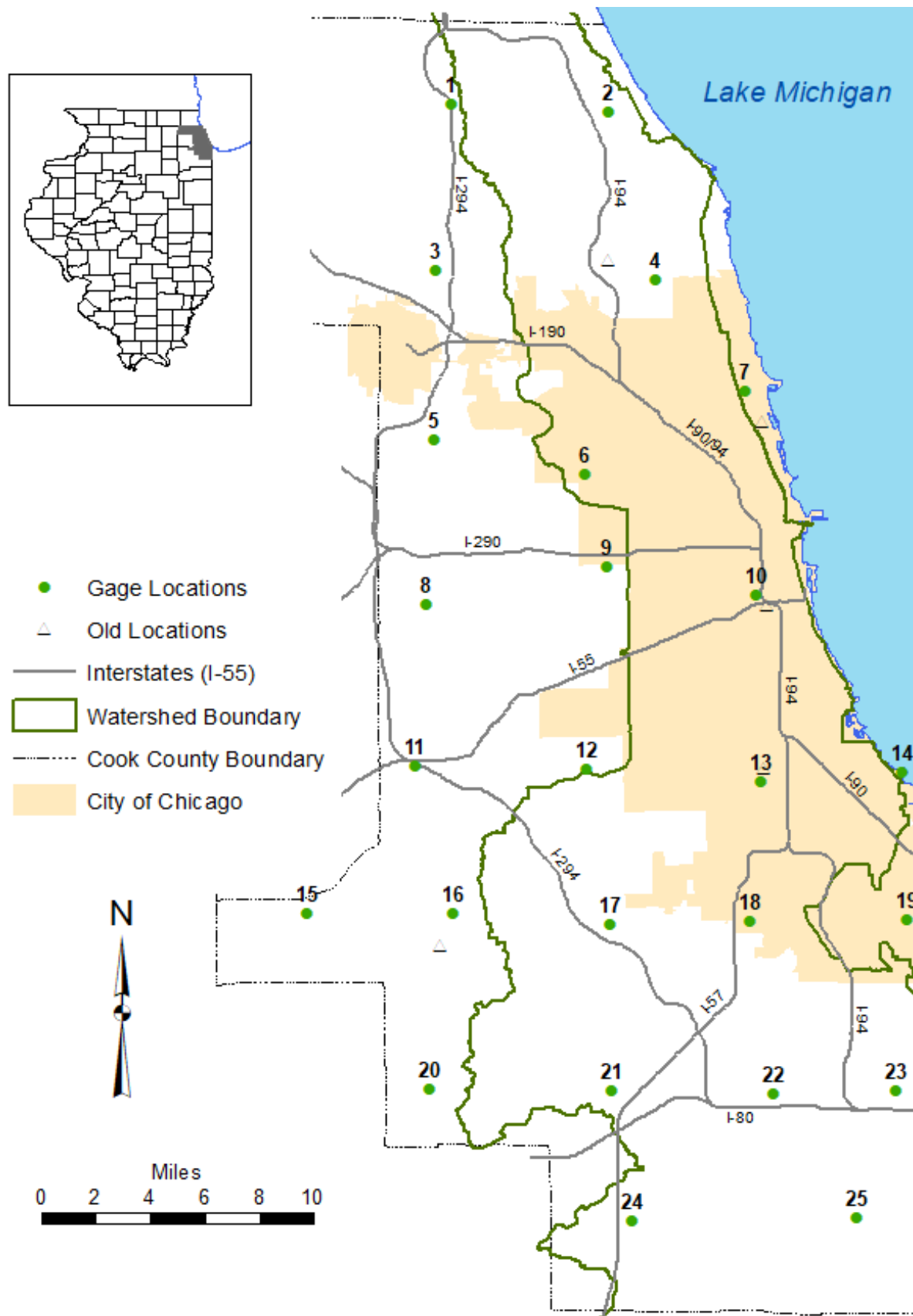


Figure 1. The Cook County 25-site raingage network for WY2018

4. DATA COLLECTION AND REDUCTION

The minimum rainfall amount recorded by the data logger is 0.01 inch every 10 minutes. Often, electronic noise is present as evidenced by 10-minute values oscillating between -0.01-inch and +0.01-inch values. Noise can be caused by wind or vibrations from proximate heavy road traffic, construction, or quarry activities. Computer software was developed to set 10-minute values to zero if within ± 10 minutes of a -0.01-inch value. Further, if an isolated positive 10-minute value is found (no other precipitation for ± 180 minutes), that value also is set to zero. These were instantaneous values.

On December 1–3, 2014, the data logger program was modified so that in addition to the instantaneous values, the 10-minute averaged values were collected at all gages except at site 12. The gage #12 program was changed on March 20, 2017 to also record the averaged values. Although the amount of noise is greatly reduced using 10-minute averages, some noise is still present. The instantaneous values are useful in examining the timing of heavy 10-minute rain rates. The instantaneous and averaged amounts add up to the same total precipitation amount. The 10-minute precipitation amounts are combined into hourly values and displayed in a format comparable to that already established for the analog chart data to eliminate more noise. Noisy values are denoted as 88.88 and missing values as 99.99. Values are usually considered part of a precipitation event if more than two adjacent gages detect precipitation during the same hour.

During the summer months, “events” often occur in the hours just after sunrise. These frequent events are believed to be related to a rapid heating of the gage, as these were not recorded by the analog charts during the years when they were in use and occur on clear sky mornings. These early morning events are manually deleted unless the National Weather Service (NWS) gages or Community Cooperative Rain, Hail, and Snow Network (CoCoRaHS) gages located in Cook County also report precipitation, or unless the NWS radar indicates precipitation.

Precipitation Data Review and Final Data Array

The precipitation data array created from the data logger data is checked for time and space consistency and storm periods are delimited. A storm is defined as a precipitation period separated from preceding and succeeding precipitation periods by approximately six hours at all stations in the network. This definition was used by Huff (1967) for an area of similar dimensions in central Illinois, by Vogel (1986) to define extreme storm events in the Chicago area, and by Vogel (1988, 1989), Peppler (1990, 1991a-c, 1993a,b, 1994, and 1995), Westcott (1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007a, 2007b, 2009a, 2010, 2011, 2012, 2013, 2014, 2015, and 2016), Bauer and Westcott (2017), and Bauer (2018) to delineate storms for WYs 1984–2017.

For each storm, observed precipitation values at each site are summed and plotted on maps using all available data and stations. If data are missing or are too noisy, a distance-weighted linear interpolation program is used to objectively determine the estimated values for missing hours. The objective routine is also used to re-create values at gage sites for which questionable storm total values are identified.

During WY2018, 131 storm events were defined for the Cook County area. Once storm period and precipitation totals have been examined and accepted, hourly and

monthly precipitation totals are analyzed and archived and isohyetal maps of the monthly or annual total precipitation are drawn.

5. DATA ANALYSIS FOR WATER YEAR 2018

The WY2018 dataset was used to produce various analyses, including:
 1) monthly and annual precipitation amounts at all sites, 2) average monthly network precipitation and monthly spatial distributions for WY2018, 3) annual network precipitation average, and 4) analysis of WY2018 precipitation with respect to the 28-year network precipitation average (1990–2017). WY2018 monthly and annual precipitation amounts for each gage are shown in Table 1.

Table 1. Monthly and Annual Precipitation Amounts for Water Year 2018 (inches)

<i>Gage</i>	<i>Oct</i>	<i>Nov</i>	<i>Dec</i>	<i>Jan</i>	<i>Feb</i>	<i>Mar</i>	<i>Apr</i>	<i>May</i>	<i>Jun</i>	<i>Jul</i>	<i>Aug</i>	<i>Sep</i>	<i>Total</i>
1	6.84	1.01	0.13	1.07	3.22	1.08	2.20	7.11	8.90	0.55	6.85	2.45	41.41
2	8.51	1.72	0.3	1.38	3.72	1.16	2.08	6.91	6.21	0.75	4.50	2.77	40.01
3	8.45	1.43	0.27	1.48	4.13	1.57	2.46	7.93	8.39	0.67	5.57	3.81	46.16
4	8.59	1.96	0.38	1.28	3.92	1.53	2.46	8.07	8.25	0.85	9.36	4.43	51.08
5	8.89	1.43	0.22	1.23	4.16	1.49	2.34	6.62	6.46	0.80	6.26	3.85	43.75
6	10.86	2.67	0.36	1.14	3.99	1.48	2.39	7.23	7.05	0.89	6.23	3.97	48.26
7	11.29	2.31	0.43	1.39	4.02	1.26	1.97	5.90	7.51	0.84	6.37	2.81	46.10
8	10.19	2.21	0.42	1.29	4.61	1.56	1.93	5.94	5.70	1.12	4.48	2.46	41.91
9	11.04	2.39	0.54	1.30	4.72	1.81	1.95	5.91	7.07	1.78	4.20	2.48	45.19
10	11.62	2.80	0.50	1.01	4.89	1.52	2.51	5.22	6.92	2.21	4.83	2.95	46.98
11	10.07	2.55	0.49	1.13	5.21	1.98	2.39	4.77	5.99	1.37	3.48	2.59	42.65
12	10.27	2.03	0.48	1.09	5.01	1.63	1.78	4.49	6.66	1.31	3.54	1.72	40.01
13	11.00	2.56	0.47	1.00	4.84	1.41	1.55	4.02	5.80	3.97	2.66	1.82	41.10
14	9.87	2.03	0.31	0.76	4.49	1.38	1.75	3.07	5.60	2.12	3.20	1.66	36.24
15	8.43	2.4	0.26	1.05	4.89	1.70	1.84	3.68	6.13	1.76	4.63	2.44	39.21
16	9.24	2.32	0.41	1.34	5.24	1.51	1.68	3.87	6.76	2.68	4.86	1.88	41.79
17	9.44	2.87	0.47	1.01	5.14	1.85	1.85	6.03	7.25	2.79	3.65	2.25	44.60
18	9.75	2.92	0.48	0.95	5.36	1.78	1.69	5.23	6.31	3.74	5.02	2.92	46.15
19	8.87	3.09	0.47	0.88	5.28	1.43	1.93	5.77	5.59	3.47	3.20	2.76	42.74
20	8.05	2.75	0.62	1.19	5.07	1.84	1.64	5.21	6.17	3.12	2.92	3.07	41.65
21	6.84	2.75	0.51	1.01	6.05	1.66	1.46	4.89	4.70	2.39	3.71	2.60	38.57
22	7.24	2.46	0.67	0.79	5.75	1.56	1.57	4.29	6.59	3.78	4.25	3.44	42.39
23	7.58	2.35	0.48	0.88	5.48	1.35	1.92	3.28	4.76	4.02	3.73	2.70	38.53
24	6.72	2.61	0.48	0.96	5.50	1.67	1.30	4.63	4.95	2.33	3.93	2.57	37.65
25	7.32	2.76	0.35	0.97	5.27	1.41	1.62	3.55	5.40	4.44	3.32	2.21	38.62
Avg	9.10	2.34	0.42	1.10	4.80	1.54	1.93	5.34	6.44	2.15	4.59	2.74	42.51

The two highest annual individual-gage precipitation amounts were greater than 48 inches during WY2018. These occurred in the northern portion of Cook County at sites #4 (51.08 inches) in Skokie, near Oakton St. and Floral Ave., and #6 (48.26 inches) in Chicago, near Belmont Ave. and Laramie Ave. The lightest amount of precipitation of WY2018 was reported at the lakeshore at site #14 (36.24 inches) in Chicago, near S. Lake Shore Dr. and E. 79th St., and in the southern end of Cook County at site #24 (37.65 inches) in Matteson, near 211th St. and Cicero Ave.

For WY2018, the total variation across the network was 14.80 inches between sites #4 and #14. Lower or higher precipitation gage totals may be due to specific storm-cell size and tracking or siting issues. Site #14 is near Lake Michigan in a very windy location; this gage has an Alter shield to help reduce the loss of the catchment due to wind. These siting differences may accentuate actual precipitation gradients between nearby gages.

Figure 2(a–l) presents the precipitation patterns for each of the 12 months in WY2018. Isohyets in the figures are labeled in inches, and values in Table 1 (above) are given to the nearest hundredth of an inch.

The monthly October 2017 network average is 9.10 inches, which is 295 percent the 28-year monthly average (1989–2016) and the highest monthly October precipitation recorded since 1989. During October 2017, eight gages received over 10 inches and four gages had over 11 inches of precipitation. Most precipitation fell within a 20-day period.

The ranges of monthly precipitation across the network during WY2018 were highest in May and August 2018, with differences in monthly precipitation between gages of 5.00 and 6.70 inches, respectively. In May, the 10 gages in the north end of Cook County collected an average of 6.68 inches, while the remaining gages (sites #11 through #25) collected an average of 4.45 inches. In August 2018, the areas around sites #4 and #18 experienced precipitation gradients of over 1 inch between adjacent gages, indicating localized heavy precipitation as is typical during the summer. December 2017 and January 2018 had the lowest average monthly precipitation of 0.42 and 1.10 inches, with variations across the network of 0.54 and 0.72 inches, respectively.

Annual precipitation isohyets for WY2018 are shown in Figure 3. Network precipitation of 42.51 inches was well above average compared to the previous 28-year network average of 36.60 inches. The network average annual precipitation amounts for WYs 1990–2017 were 40.00, 39.19, 36.56, 51.78, 29.23, 34.68, 36.88, 34.09, 36.12, 36.33, 33.33, 36.39, 33.37, 29.03, 35.24, 27.29, 35.89, 41.47, 43.44, 40.85, 44.46, 41.78, 28.30, 34.62, 40.53, 32.30, 37.56, and 34.04 inches, respectively. Appendix VII provides isohyetal maps of annual precipitation for each individual water year 1990 through 2017.

The network's WY2018 average precipitation is 42.51 inches and the 29-year (1990–2018) average annual total is 36.80 inches. WY2018 is the fourth wettest year of the past 29 years. WY2018 was about 115 percent of the previous 29 year network average and 115 percent of the 1981–2010 Chicago O'Hare Airport annual precipitation normal of 36.89 inches.

In WY2018, the total precipitation pattern (Figure 3) is dominated by a broad oblong region of high precipitation in the northern half of Cook County centered on Skokie and the north side of Chicago. To the south of this regional high area of precipitation is an east-west region of lower precipitation near Midway Airport that crosses the county. Further south is another broad region of higher precipitation centered near site #18 (Calumet Park).

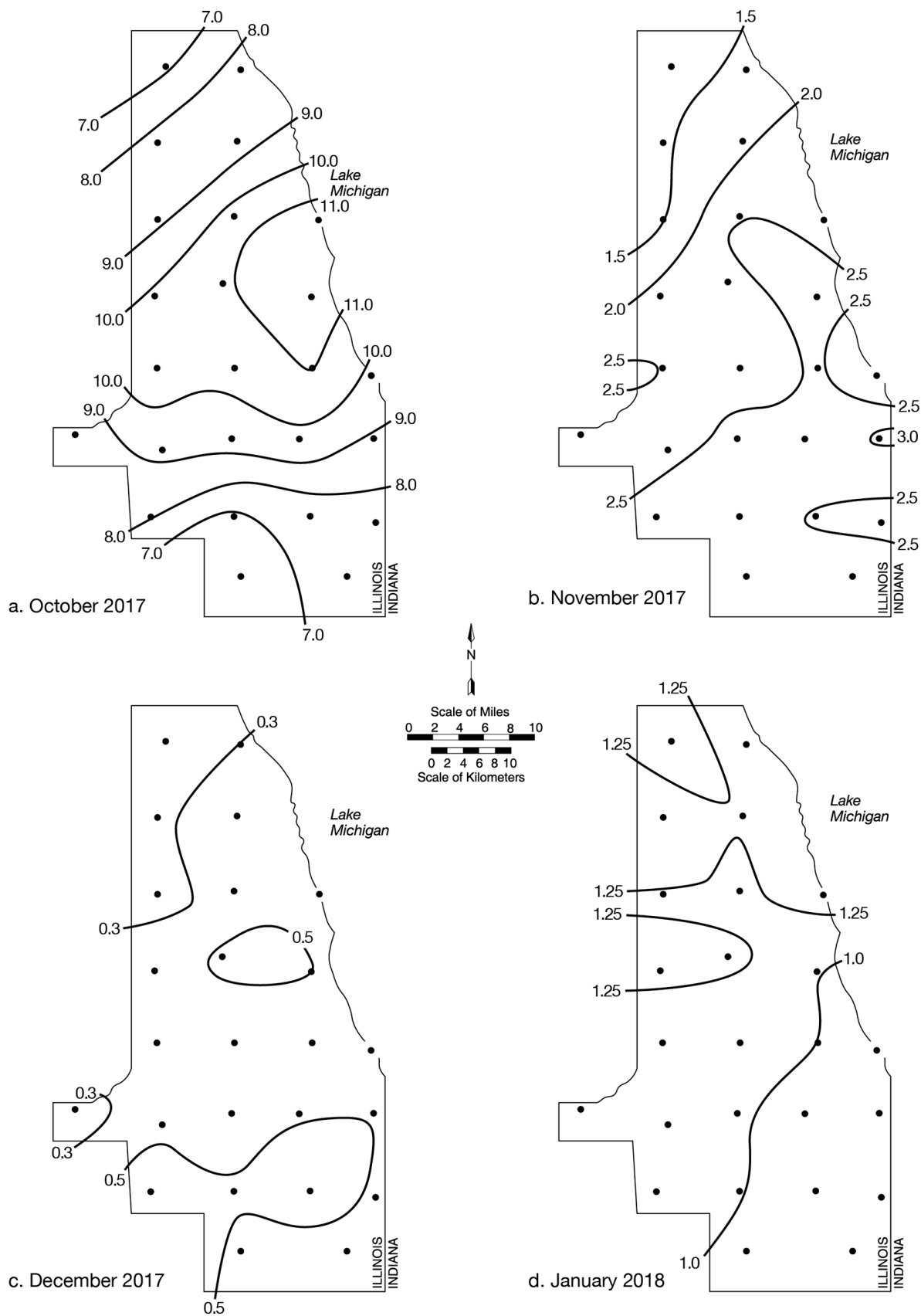


Figure 2(a–d). WY2018 monthly precipitation isohyets (inches)

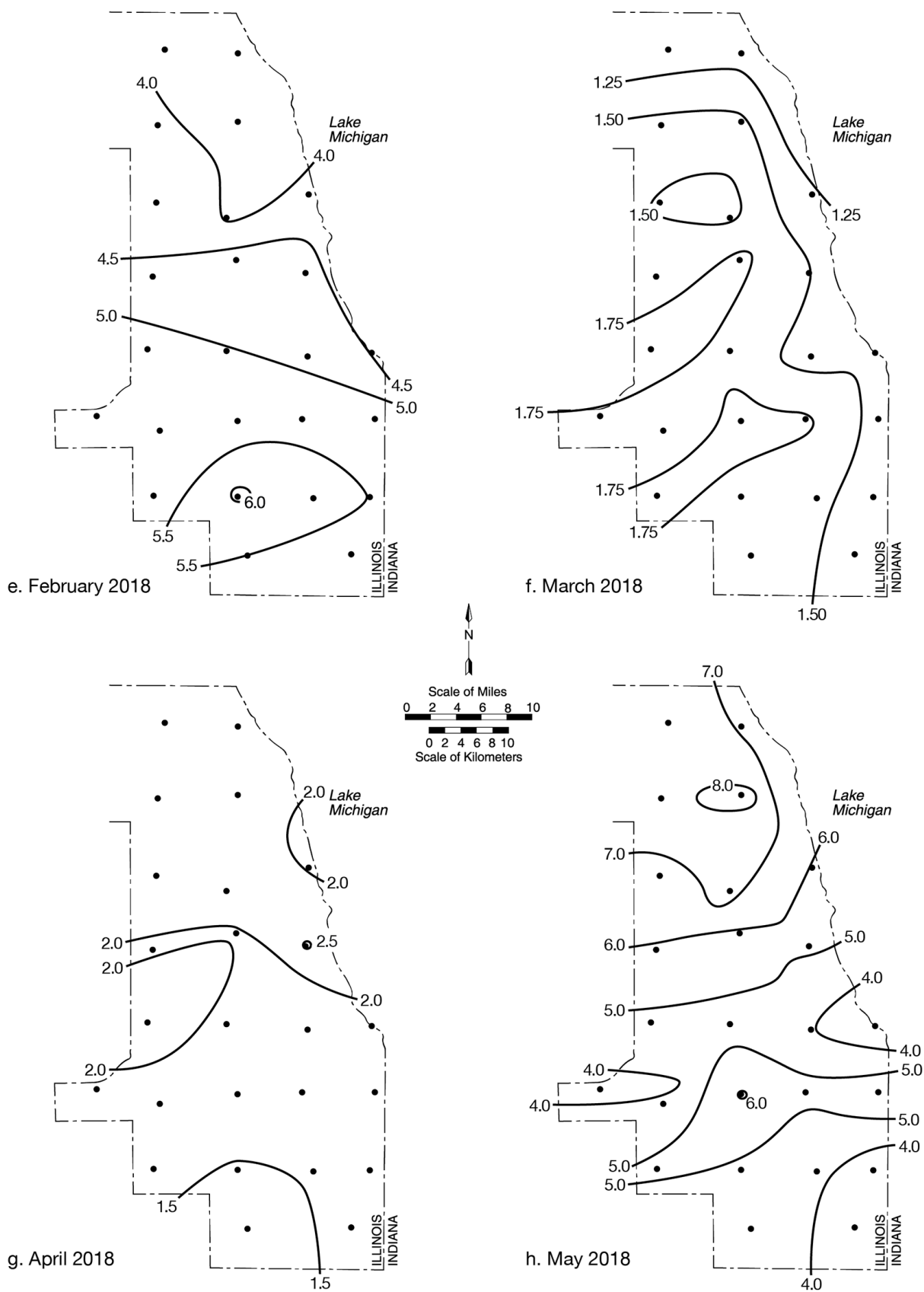


Figure 2(e–h) continued. WY2018 monthly precipitation isohyets

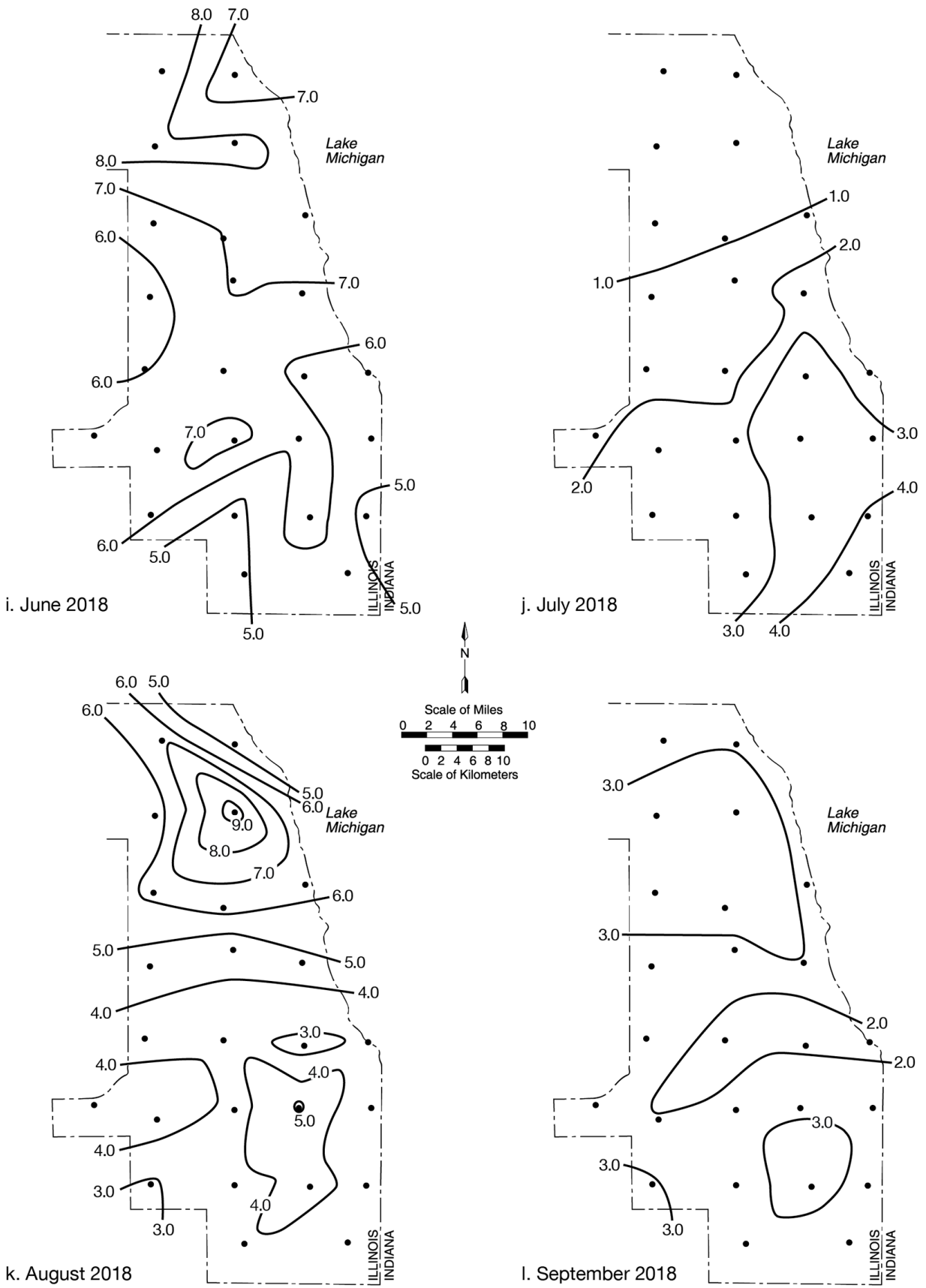


Figure 2(i-l) concluded. WY2018 monthly precipitation isohyets

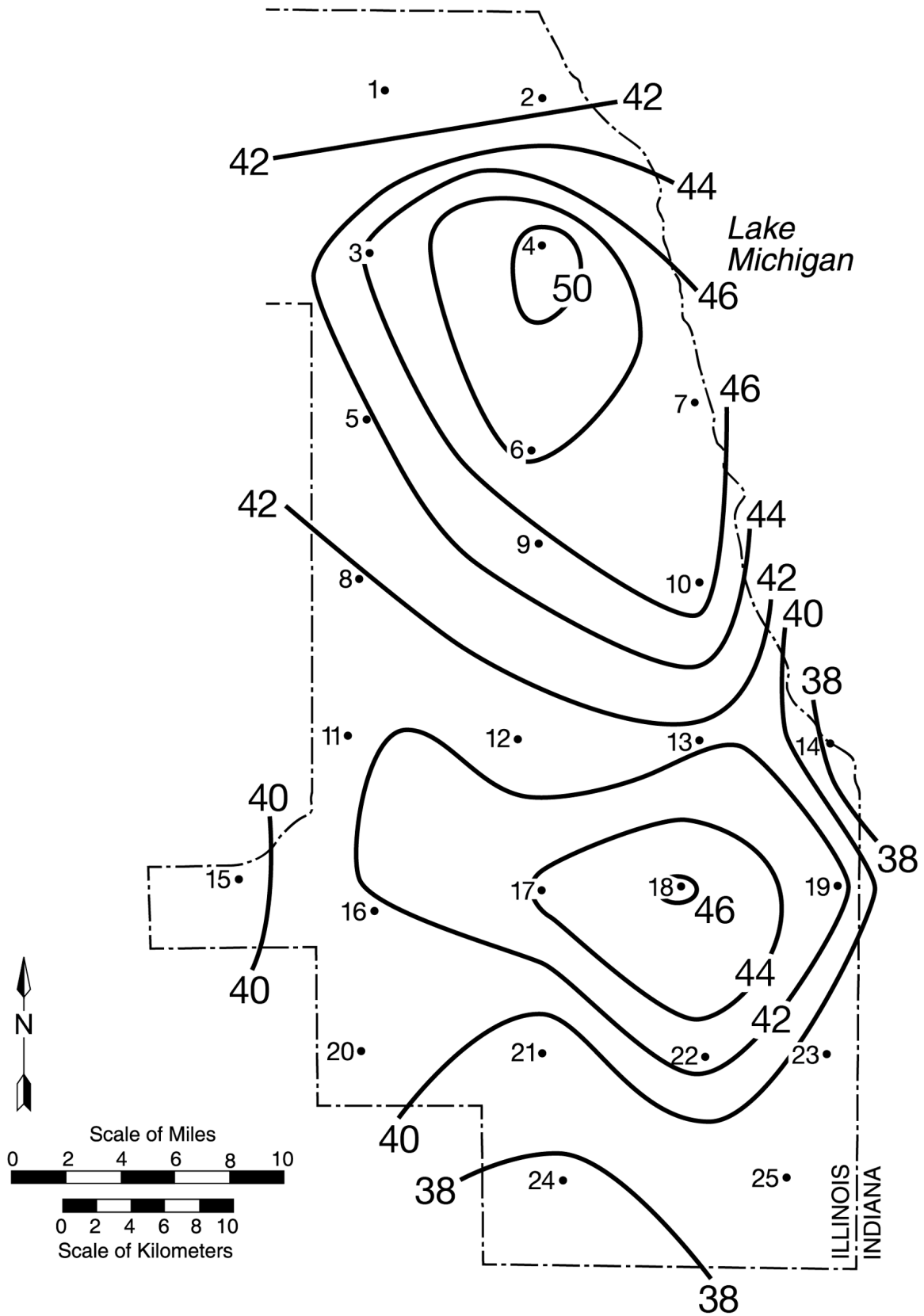


Figure 3. Precipitation isohyets (inches) for WY2018 (Oct. 2017–Sept. 2018)

The largest difference between adjacent gages for WY2018 is 10.76 inches, which occurs between site #10 in the central part of the city of Chicago and site #14 on the lakeshore near the Illinois-Indiana border. All other lower precipitation totals (below 40 inches) occurred in the southernmost part of Cook County.

Heavy Precipitation Event Recurrence

For high precipitation events, storm durations of one hour to three days were considered, and recurrence intervals were determined according to the standards set for northeastern Illinois (Huff and Angel, 1989). See [Appendix VIII](#) for precipitation thresholds for 1-year to 100-year storm events.

Individual storms are defined when precipitation at all 25 gages is separated by six hours or more. The precipitation threshold for a 1-year to 100-year storm is reached when the precipitation total for a given duration met or exceeded the precipitation amounts in [Appendix VIII](#) (Table VIII-1). Five of the 131 precipitation events in WY2018 exceeded the 1-year recurrence interval (Table 2). On average, seven heavy precipitation events exceeding the 1-year recurrence interval occurred annually during WYs 1990–2018.

On October 10, 2017, site #13 precipitation exceeded the 1-year storm recurrence frequency. On October 14, 2017, seven gages exceeded the 25-year, five gages exceeded the 10-year, five exceeded the 5-year, five gages exceeded the 2-year, and three gages exceeded the 1-year storm frequency. On February 19, 2018, nine gages exceeded the 2-year and nine other gages exceeded the 1-year storm frequency. On June 20, 2018, two gages exceeded the 5-year, nine gages exceeded the 2-year, and 10 gages exceeded the 1-year storm frequency. On August 7, 2018, one gage exceeded the 1-year storm frequency. During WY2018, no gages exceeded the 50-year or 100-year storm recurrence intervals.

Table 2. Storm Event Totals for WY2018 Heavy Precipitation Events

<i>Storm #</i>	<i>Date</i>	<i>Site #</i>	<i>Duration (hours)</i>	<i>Amount (inches)</i>	<i>Storm Recurrence Frequency</i>
5	10/10/2017	13	18	2.45	1-year
6	10/14/2017	1	29	3.52	2-year
6		2	29	4.15	5-year
6		3	29	4.14	5-year
6		4	31	4.1	5-year
6		5	28	4.73	10-year
6		6	30	6.31	25-year
6		7	31	6.36	25-year
6		8	30	6.4	25-year
6		9	29	6.45	25-year
6		10	29	6.12	25-year
6		11	30	5.92	25-year
6		12	29	5.69	25-year
6		13	31	5.55	10-year
6		14	29	5.19	10-year
6		15	29	4.66	10-year
6		16	28	5.32	10-year
6		17	29	4.4	5-year
6		18	31	4.51	5-year
6		19	29	3.52	2-year
6		20	29	3.49	2-year
6		21	29	2.87	1-year
6		22	29	3.36	2-year
6		23	29	3.32	2-year
6		24	28	2.84	1-year
6	10/14/2017	25	28	2.85	1-year
57	2/19/2018	8	44	2.94	1-year
57		9	45	2.99	1-year
57		10	44	3.14	1-year
57		11	44	3.55	2-year
57		12	44	3.23	1-year
57		13	43	3.15	1-year
57		14	51	2.97	1-year
57		15	48	3.14	1-year
57		16	45	3.34	1-year
57	2/19/2018	17	45	3.2	1-year

57	2/19/2018	18	47	3.37	2-year
57		19	46	3.56	2-year
57		20	52	3.54	2-year
57		21	51	3.94	2-year
57		22	53	3.88	2-year
57		23	53	3.48	2-year
57		24	49	3.66	2-year
57	2/19/2018	25	48	3.67	2-year
99	6/20/2018	3	36	2.9	1-year
99		4	35	3.65	2-year
99		6	38	3.22	2-year
99		7	36	3.37	2-year
99		8	36	2.93	1-year
99		9	35	3.04	1-year
99		10	34	3.75	2-year
99		11	33	3.04	1-year
99		12	37	2.78	1-year
99		13	32	3.03	1-year
99		14	32	3.58	2-year
99		16	38	3.41	2-year
99		17	36	4.37	5-year
99		18	37	4.01	5-year
99		19	34	3.04	1-year
99		20	36	3.2	1-year
99		21	37	2.79	1-year
99		22	37	3.6	2-year
99		23	36	2.94	1-year
99		24	40	3.62	2-year
99	6/20/2018	25	35	3.53	2-year
119	8/7/2018	5	3	2.28	1-year
119		7	5	2.43	1-year

Figure 4 presents the WY2018 monthly average network precipitation along with the previous 28-year monthly average precipitation. For WY2018, the monthly precipitation was highest in October 2017 with 9.10 inches. This amount is 296 percent of the average (3.08 inches) of the previous 28-Octobers. Most of the October precipitation came within a five-day period. May and June 2018 had the second and third highest precipitation, 5.34 and 6.44 inches, respectively. Although February 2018 had the fourth highest monthly precipitation of 4.80 inches, it was 151 percent of the 28-year February monthly average. Precipitation totals were well below the 28-year monthly average during December 2017 and January, March, April, and July 2018. December 2017 only had about 17 percent of the 28-year average monthly precipitation.

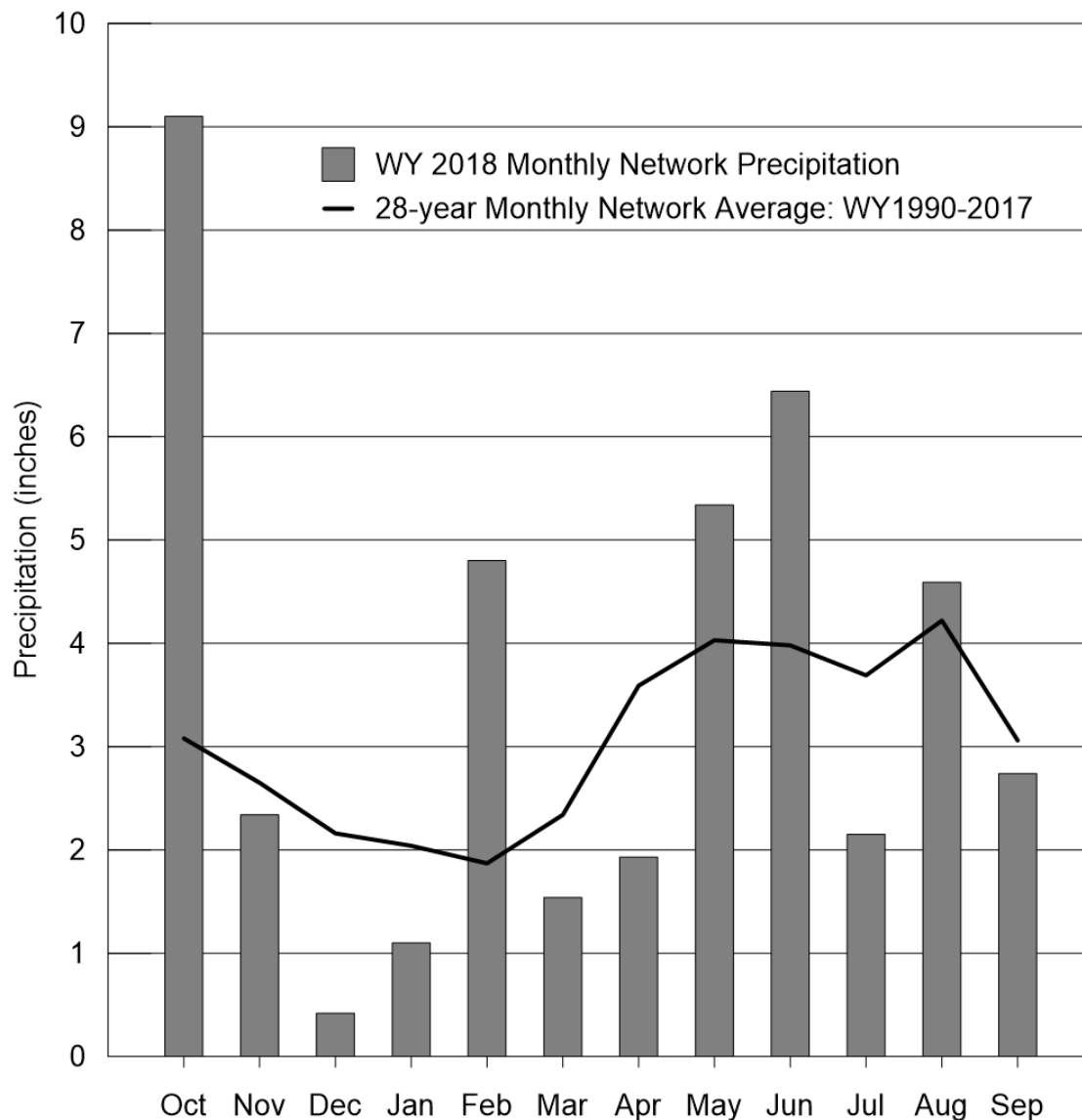


Figure 4. WY2018 monthly network precipitation compared to the previous 28-year monthly average network precipitation

Twenty-Nine Year Average Precipitation Distribution

The highest 29-year (1990–2018) average precipitation totals by site are 39.54 inches at site #10, 38.10 inches at site #17, and 38.07 inches at site #9. The 29-year network-wide average is 36.80 inches with a variation across the network of 5.11 inches.

The 29-year average annual precipitation isohyets are shown in Figure 5. The 36-inch and 37-inch isohyets run roughly parallel to each other and along the shoreline for almost 25 miles from Skokie to near the Illinois-Indiana border. This pattern may be expected, given the tendency for Lake Michigan to decrease spring and summer precipitation along the shore. The 37-inch isohyet delineates a broad arc of higher rainfall amounts (> 37 inches) beginning between site #4 in Skokie and site #6 in Hanson Park, running parallel to the shore until bending southwest near Burnham. Lower than average precipitation amounts were collected at the near shore gages (sites #7 and #14) and north of Fullerton Avenue at sites #1, #2, #3, #4, #5, and #7.

Water year 2018 has the fourth highest network average annual precipitation in the past 29 years, after WY1993 (51.78 inches), WY2010 (44.46 inches), and WY2008 (43.44 inches). The eight years with the highest annual precipitation amounts, greater than 40.52 inches, have occurred within the past 11 years.

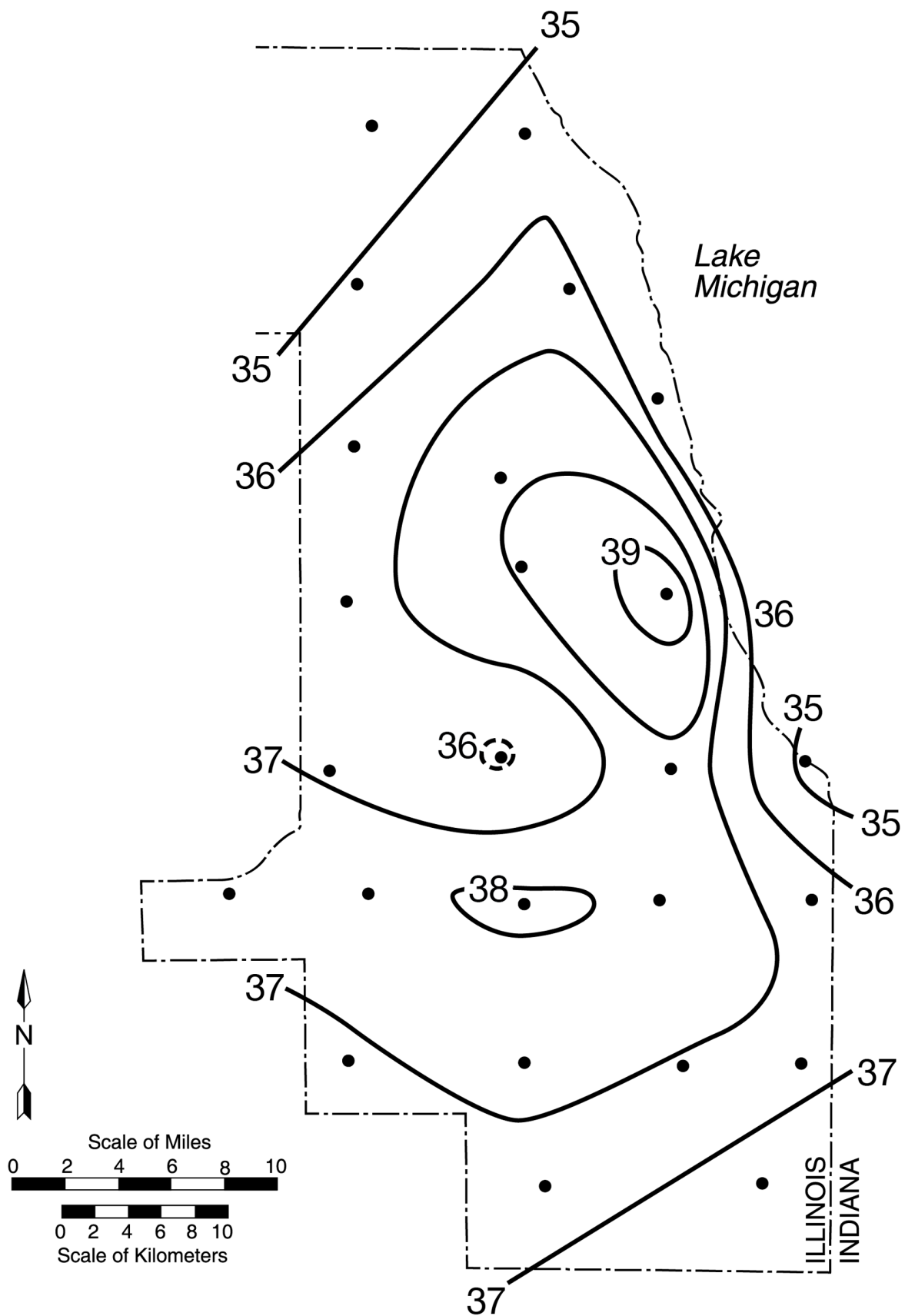


Figure 5. The 29-year average precipitation pattern (inches), WYs 1990–2018

6. SUMMARY

The Cook County raingage network has collected precipitation data for 29 water years, 1990–2018. The annual network precipitation average of the 25-gage amounts in WY2018 is 42.51 inches, 5.91 inches higher or 16 percent higher than the previous 28-year network average of 36.59 inches and 15 percent higher than the 1981–2010 Chicago O'Hare Airport annual precipitation normal of 36.89 inches.

The most recent three days of 10-minute and hourly provisional data can be obtained in real time online at <http://www.isws.illinois.edu/data/ccprecipnet/livedata.asp>. Siting of the gages, areal coverage of the network, installation of potentiometers and data loggers, and careful quality control of the data allow the USACE, Chicago District, to accurately estimate the storm runoff portion of the diversion of water from Lake Michigan into Illinois. Because of the relatively dense spacing of the raingages, the network also provides high-quality data for research on precipitation variability of the Cook County region.

7. ACKNOWLEDGMENTS

This material is based on work supported by the U.S. Army Corps of Engineers, Chicago District, under Contract No. W912P6-08-C-0029. Jeff Fuller, U.S. Army Corps of Engineers, Chicago District, administered the project. David Kristovich and James Angel served as co-principal investigators providing general project guidance and—in particular—expertise on the specific local atmospheric influences in Cook County. Dana Grabowski serviced and maintained the gages. Kevin Merrifield was responsible for the web page design, implementation, and maintenance. Danielle Ruffatto and Mike Knapp provided graphic support for the figures, and Lisa Sheppard edited the report. Leslie Stoecker wrote the distance-weighted interpolation program to fill missing hourly data. Any opinions, findings, and conclusions or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the United States Army Corps of Engineers, the Illinois State Water Survey, the Prairie Research Institute, or the University of Illinois.

8. REFERENCES

- Bauer, E., 2018: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2017*. Illinois State Water Survey Contract Report 2018-03, 91p.
- Bauer, E. and N.E. Westcott, 2017: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2016*. Illinois State Water Survey Contract Report 2017-03, 86p.
- Changnon, S.A., 1961: Precipitation contrasts between the Chicago urban area and an offshore station in southern Lake Michigan. *Bulletin of the American Meteorological Society*, **42**, 1–10.
- Changnon, S.A., 1968: *Precipitation Climatology of Lake Michigan Basin*. Illinois State Water Survey Bulletin **52**, 46p.
- Changnon, S.A., 1980: Evidence of urban and lake influences on precipitation in the Chicago area. *Journal of Applied Meteorology*, **19**, 1137–1159.
- Changnon, S.A., 1984: Urban and lake effects on summer rainfall in the Chicago area. *Physical Geography*, **4**, 1–23.
- He, X., J. Koch, C. Zheng, T. Bøvith, and K.H. Jensen, 2018: Comparison of Simulated Spatial Patterns Using Rain Gauge and Polarimetric-Radar-Based Precipitation Data in Catchment Hydrological Modeling. *J. Hydrometeor.*, **19**, 1273–1288, <https://doi.org/10.1175/JHM-D-17-0235.1>
- Huff, F.A., 1967: Time distribution of rainfall in heavy storms. *Water Resources Research*, **3**, 1007–1019.
- Huff, F.A., 1970: Sampling errors in measurement of mean precipitation. *Journal of Applied Meteorology*, **9**, 35–44.
- Huff, F.A., 1979: *Spatial and Temporal Correlation of Precipitation in Illinois*. Illinois State Water Survey Circular 141, 14p.
- Huff, F.A., and J.R. Angel, 1989: *Frequency Distributions and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois*. Illinois State Water Survey Bulletin 70, 177p.
- Huff, F.A., and S.A. Changnon, 1973: Precipitation modification by major urban areas. *Bulletin of the American Meteorological Society*, **54**, 1220–1232.
- Huff, F.A., and J.L. Vogel, 1976: *Hydrometeorology of Heavy Rainstorms in Chicago and Northeastern Illinois*. Illinois State Water Survey Report of Investigation 82, 63p.

- Jones, D.M.A., 1969: Effect of housing shape on the catch of recording gages. *Monthly Weather Review*, **97**, 604–606.
- Koschmieder, H., 1934: Methods and results of definite rain measurements. *Monthly Weather Review*, **62**, 5.
- Legates, D.R., and C.J. Willmott, 1990: Mean seasonal and spatial variability in gauge-corrected, global precipitation. *International Journal of Climatology*, **10**, 111–127.
- Lindroth, A., 1991: Reduced loss in precipitation measurements using a new wind shield for raingages. *Journal of Atmospheric and Oceanic Technology*, **8**, 444–451.
- Peppler, R.A., 1990: *Reduction of 1987 Water Year Precipitation Data for Lake Michigan Diversion Accounting*. Illinois State Water Survey Contract Report 498, 16p.
- Peppler, R.A., 1991a: *Reduction and Adjustment of Water Year 1988 and Water Year 1989 Precipitation Data for Lake Michigan Diversion Accounting*. Illinois State Water Survey Contract Report 510, 24p.
- Peppler, R.A., 1991b: *Installation and Operation of a Dense Raingage Network to Improve Precipitation Measurements for Lake Michigan Diversion Accounting: Water Year 1990*. Illinois State Water Survey Contract Report 517, 87p.
- Peppler, R.A., 1991c: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 1991*. Illinois State Water Survey Contract Report 520, 65p.
- Peppler, R.A., 1993a: *Reduction and Adjustment of 1986 Water Year Precipitation Data for Lake Michigan Diversion Accounting*. Illinois State Water Survey Contract Report 550, 13p.
- Peppler, R.A., 1993b: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 1992*. Illinois State Water Survey Contract Report 551, 59p.
- Peppler, R.A., 1994: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 1993*. Illinois State Water Survey Contract Report 573, 60p.
- Peppler, R.A., 1995: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 1994*. Illinois State Water Survey Contract Report 585, 60p.
- USACE Chicago District, 2012: *Lake Michigan Diversion Accounting Water Year 2012 Report*, 53p.

- Vogel, J.L., 1986: *Significant Storm Distribution in Chicago, 1949-1979*. Illinois State Water Survey Contract Report 388, 30p.
- Vogel, J.L., 1988: *An Examination of Chicago Precipitation Patterns for Water Year 1984*. Illinois State Water Survey Contract Report 449, 44p.
- Vogel, J.L., 1989: *Reduction of 1985 Water Year Precipitation Data for Chicago*. Illinois State Water Survey Contract Report 459, 15p.
- Westcott, N.E., 1996: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 1995*. Illinois State Water Survey Contract Report 601, 48p.
- Westcott, N.E., 1997: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 1996*. Illinois State Water Survey Contract Report 618, 50p.
- Westcott, N.E., 1998: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 1997*. Illinois State Water Survey Contract Report 628, 51p.
- Westcott, N.E., 1999: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 1998*. Illinois State Water Survey Contract Report 647, 52p.
- Westcott, N.E., 2000: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 1999*. Illinois State Water Survey Contract Report 2000-07, 52p.
- Westcott, N.E., 2001: *Continued Operation of a Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2000*. Illinois State Water Survey Contract Report 2001-02, 52p.
- Westcott, N.E., 2002: *Operation, Maintenance, and Upgrade of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2001*. Illinois State Water Survey Contract Report 2002-03, 57p.
- Westcott, N.E., 2003: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2002*. Illinois State Water Survey Contract Report 2003-01, 58p.

- Westcott, N.E., 2004: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2003*. Illinois State Water Survey Contract Report 2004-03, 60p.
- Westcott, N.E., 2005: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2004*. Illinois State Water Survey Contract Report 2005-01, 62p.
- Westcott, N.E., 2006: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2005*. Illinois State Water Survey Contract Report 2006-02, 67p.
- Westcott, N.E., 2007a: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2006*. Illinois State Water Survey Contract Report 2007-01, 65p.
- Westcott, N.E., 2007b: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2007*. Illinois State Water Survey Contract Report 2007-09, 67p.
- Westcott, N.E., 2009a: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2008*. Illinois State Water Survey Contract Report 2009-04, 69p.
- Westcott, N.E., 2009b: Differences in multi-sensor and raingage precipitation amounts. *Proceedings of the Institution of Civil Engineers, Water Management*, **162** (MW2), 73–81.
- Westcott, N.E., 2010: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2009*. Illinois State Water Survey Contract Report 2010-03, 68p.
- Westcott, N.E., 2011: *Upgrade and Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2010*. Illinois State Water Survey Contract Report 2011-05, 74p.
- Westcott, N.E., 2012: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2011*. Illinois State Water Survey Contract Report 2012-02, 76p.

- Westcott, N.E., 2013: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2012*. Illinois State Water Survey Contract Report 2013-01, 76p.
- Westcott, N.E., 2014: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2013*. Illinois State Water Survey Contract Report 2014-01, 80p.
- Westcott, N.E., 2015: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2014*. Illinois State Water Survey Contract Report 2015-01, 86p.
- Westcott, N.E., 2016: *Continued Operation of a 25-Raingage Network for Collection, Reduction, and Analysis of Precipitation Data for Lake Michigan Diversion Accounting: Water Year 2015*. Illinois State Water Survey Contract Report 2016-01, 82p.
- Westcott, N.E., H.V. Knapp, and S.D. Hilberg, 2008: Comparison of gage and multi-sensor precipitation estimates over a range of spatial and temporal scales. *Journal of Hydrology*, **351** (1-2), 1–12.

APPENDIX I: LAKE MICHIGAN DIVERSION ACCOUNTING METHOD AND PRE-1990 PRECIPITATION NETWORK¹

The primary components of Illinois' diversion from Lake Michigan are as follows: 1) the water that is pumped directly from Lake Michigan as the source of potable water supply and discharged into the river and canal system in the greater Chicago area as treated sewage, 2) the storm runoff that is discharged from the diverted watershed area of Lake Michigan drains to the river and canal system, and 3) the water that enters the river and canal system directly from Lake Michigan.

Storm runoff from the Lake Michigan watershed basin enters combined and separate sewer systems and watercourses. The combined sewers mix sanitary system flow with runoff, and this water then goes to treatment plants or, during major flood events, is discharged into the watercourses. When large storm events are predicted (and greater than normal storm runoff is anticipated), the canal system is drawn down prior to the event to prevent flooding. If the event fails to materialize, canal system levels are restored using a direct diversion from Lake Michigan through two facilities located at the lakefront: the Chicago River Controlling Works and the O'Brien Lock and Dam.

The method for computing the diversion involves the direct measurement of diversion flow at Lemont, Illinois, as measured by an acoustic velocity meter. Flow at Lemont consists of both diversion and non-diversion flows (deductions). The theory behind diversion accounting is to use the flow at Lemont and deduct from it flows not attributable to diversion. Diversion flows that bypass Lemont are added to the resultant flow, yielding a net computed diversion of water from Lake Michigan. Deductions to the Lemont record include runoff from 217 square miles of the Des Plaines River watershed that is discharged into the canal, the groundwater supply whose effluent is discharged into the canal, water used by federal facilities, and the Indiana water supply that is discharged into the canal via the Calumet River system and the Calumet Sag Channel.

The diversion is approximated by adding the Lake Michigan water supply pumpage, direct diversions from Lake Michigan, and runoff from 673 square miles of the diverted Lake Michigan watershed. This approximation is performed to cross-check the computed diversion.

In both procedures, it is necessary to estimate runoff from the Des Plaines River and the Lake Michigan watersheds. Hydrologic simulations of runoff perform two functions. One function is to model runoff. The second function is to aid in determining the inflow, infiltration, and sanitary proportions of treatment plant discharge. Inputs into the simulation model consist of land-use, hydrological parameters, and climatological data. Of the latter, the most significant are precipitation data.

1: Historical information has been included in this report as required by the sponsor. Appendix I content was reproduced from Bauer, 2018 and updated for WY2018.

Thus, accurate precipitation data are essential to properly simulate the runoff process. Runoff can constitute a significant portion of the diversion. For example, for WY 2012 (October 1, 2011 through September 30, 2012), runoff from the Des Plaines River watershed constituted a 138.7 cfs (6.1 percent) deduction from the Lemont measurement record in the diversion computations. In the cross-check approximations, the Lake Michigan watershed runoff constituted a 623 cfs (28 percent) share of the total allowed diversion (USACE Chicago District, 2012).

However, the precipitation data available for use by the accounting procedure prior to WY 1990 (particularly WYs 1984–1989) displayed patterns inconsistent with known long-term Chicago area patterns (e.g., Changnon, 1961, 1968; Huff and Changnon, 1973; Vogel, 1988, 1989; Pepler, 1990, 1991a, 1993a). These patterns also diverge from the known urban effects found within the precipitation patterns for the Cook County region for heavier rainfall 1949–1974 distributions (Huff and Vogel, 1976), particularly toward the south, and within patterns observed during the operation of a dense raingage network and radar system in the Chicago area during the late 1970s (Changnon, 1980, 1984).

The unusual patterns were caused by abnormally low precipitation totals at a select number of the 13 sites used by the accounting procedure (Figure I-1). Inspection of these sites (Vogel, 1988), which are irregularly distributed over the region, revealed that low precipitation totals were caused by 1) inadequate gage exposure (e.g., gages situated on rooftops or too close to natural or artificial air flow-restricting obstructions) and 2) different observation, data reduction, and quality control practices used by the individual groups responsible for raingage operation and data collection (National Weather Service - NWS, Metropolitan Water Reclamation District of Greater Chicago - MWRDGC, and City of Chicago - CC). Vogel (1988) established that the unusual precipitation patterns began occurring in the late 1960s when some changes were made in data collection and reduction.

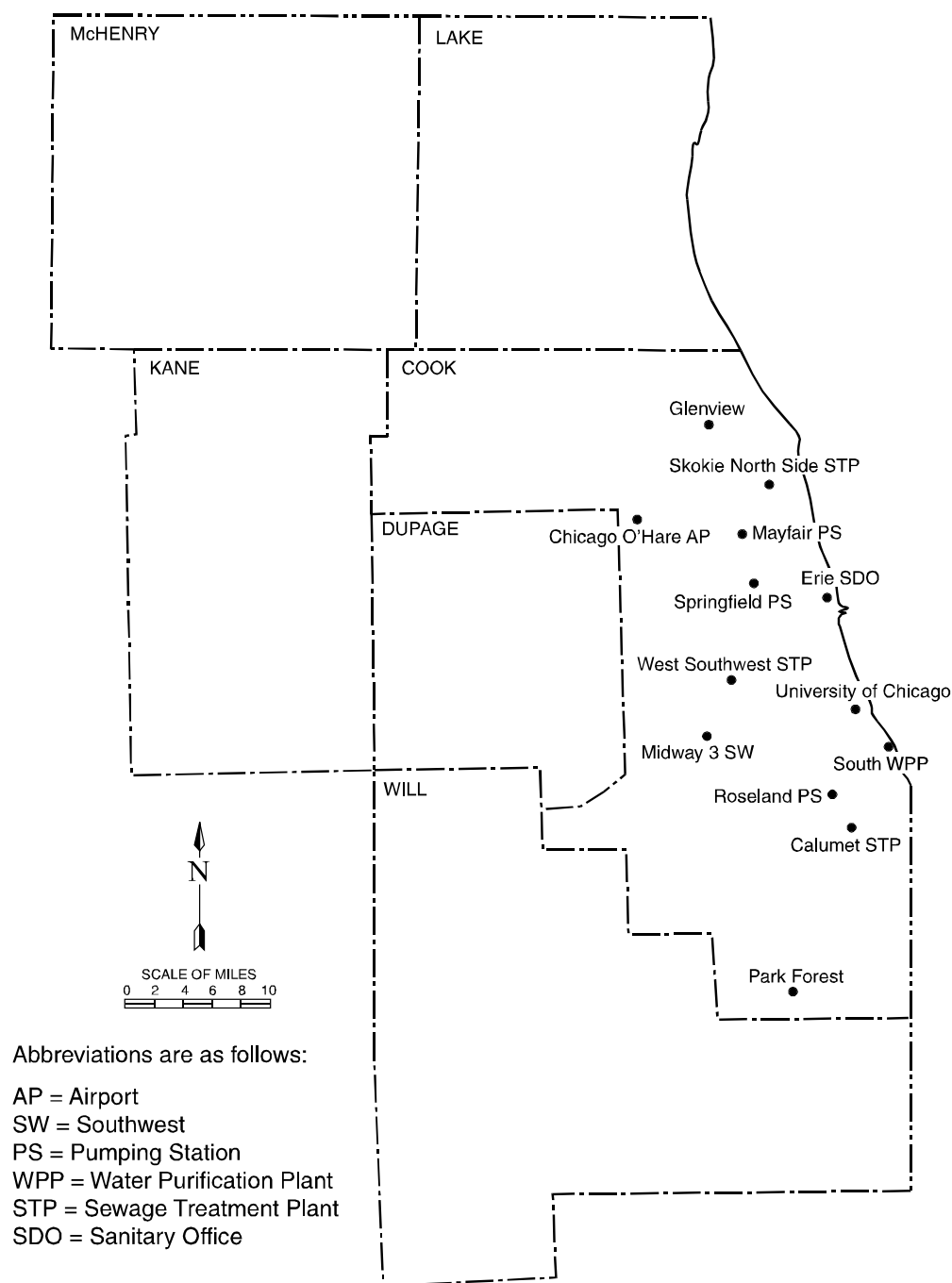


Figure AI-1. Raingauge locations used for diversion accounting purposes prior to WY 1990. These include National Weather Service gages located at Chicago O'Hare AP, Midway 3 SW, University of Chicago, and Park Forest; City of Chicago gages located at Mayfair PS, Springfield PS, South WPP, and Roseland PS; and Metropolitan Water Reclamation District of Greater Chicago gages located at Glenview, Skokie North Side STP, Erie SDO, West Southwest STP, and Calumet STP.

Vogel (1988) devised a method to adjust the questionable values, thus making the data suitable for use in the accounting procedure. This method was tedious to implement, however, and the adjusted precipitation values may not have completely captured the actual precipitation regime, although the data produced were much improved from the original values. This procedure also illuminated difficulties experienced when trying to merge data observations from different agencies and equipment into one dataset. Vogel (1988) gave the following recommendation at the end of his report on the reduction and adjustment of the WY 1984 data and on field evaluations of the NWS, MWRDGC, and CC sites:

“With these types of differences it will always be hard to maintain a consistent set of high-quality precipitation observations for the Chicago urban region. A precipitation network which must produce a set of high-quality observations should have a consistent set of gages; should be managed by one group with fixed quality control procedures, exposure criteria, and a set operating procedure. Management by one group would allow for consistent 1) observations, 2) quality control, and 3) spatial and temporal precipitation patterns.

“To achieve this, it is recommended that a raingage network be established to monitor the precipitation over northeast Illinois relevant to the diversion of Lake Michigan waters. This network should consist of 10 to 15 weighing-bucket-recording raingages. The raingages should be reasonably spaced across the affected area. The network should be managed by one group to ensure that the best possible exposures are obtained initially, and that these exposures are inspected at least annually. The data from such a network should all be quality-controlled in a consistent manner.

“Weighing-bucket raingages with daily charts would be capable of obtaining hourly or smaller time increments if daily charts are used. To reduce costs and to increase security, it is recommended that these raingages be located on private property, and that the observers be given a modest annual stipend. The charts from the observers should be mailed to a central location for data processing, quality control, and extraction of hourly precipitation totals. Raingages should be evenly spaced, as much as possible, and sites would be found after consulting with the agencies involved (pp. 41–42).

Using Vogel's recommendation as a model, the Illinois State Water Survey (ISWS) and the USACE jointly decided in late 1988 to devise, install, and operate a new raingage network, funded by the USACE. The purpose of the new network was to produce consistent, accurate data for the diversion accounting, which would require little or no adjustment. Implementation and operation of such a network would have to be justified on the grounds of both long-term cost savings and greater accuracy.

APPENDIX II: NETWORK DESIGN METHODOLOGY²

The ISWS has operated dense raingage networks in the past (e.g., Huff, 1970, 1979), which tested gage grid spacings from 6 feet to 6 miles. Adequate sampling of convective precipitation (typical in spring and summer) was found to require nearly twice as many gages for more widespread, long-lived precipitation (fall and winter). With that in mind, and opting for optimum grid spacing, an initial attempt at creating a grid-style raingage network resulted in an array of 40 gages located in the Cook County region in the Lake Michigan and Des Plaines River watersheds of the MWRDGC North, Central, South, and Lemont basins. Due to cost considerations, however, some spring/summer catchment ability was sacrificed, and a 25-site grid was devised using 5- to 7-mile grid spacing between gages. Also due to cost considerations, gages were not installed outside the watershed boundaries to better define isohyetal patterns at those boundaries. These 25 gages, more than the 10 to 15 gages Vogel had originally envisioned, have provided adequate coverage for precipitation catchment since the inception of the network in 1990 (Pepler, 1991b, 1991c, 1993b, 1994, 1995; Westcott, 1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007a, 2007b, 2009a, 2010, 2011, 2012, 2013, 2014, 2015, 2016; Bauer and Westcott, 2017) and are consistent with the "best current engineering practice" as specified in the 1967 and 1980 United States Supreme Court decrees. Other sources of precipitation characterizations are now available, such as surface- and satellite-based radar estimates. Even with the advanced usage of polarization techniques, current research and data use emphasize the utility of radar- and multi-sensor-precipitation data as useful for estimating spatial variations, while "rain gage data are mainly responsible for obtaining the correct" mean precipitation values (He et al., 2018).

In 1989, topographic maps of the Cook County region were used to approximate the location of each of the 25 sites and fine-tune their placement to best position the sites with respect to residential areas, industrial facilities, or municipal grounds. Because terrain effects are fairly minimal in northeastern Illinois, gridding was possible. Gridding also allows the use of simple arithmetic averaging to compute areal depths instead of other labor-intensive methods such as the Thiessen polygonal method.

Once candidate locations were found, several preliminary field trips were made to the Cook County region, and letters were written by ISWS staff in summer 1989 seeking permission to use the selected locations as raingage sites. Due to the urbanization of the region, site selection was sometimes a frustrating venture, as it was difficult in many instances to identify good catchment areas free of barriers for ground-level placement. When selecting sites, the highest priority was given to those at ground level in relatively open, secure areas. This is because obstructions and local wind eddies produced by flow barriers present the largest sources of error in collecting precipitation data. Placing the collector at ground level reduces wind effects on catchment and represents the ideal exposure (Legates and Willmott, 1990), but it is not practical in wintertime when snow is measured. Thus, as has been standard ISWS practice, each gage was placed on stakes

2: Historical information has been included in this report as required by the sponsor. Appendix II content was reproduced from Bauer, 2018 and updated for WY2018.

with its base approximately 8 inches above ground level and the top of its orifice at about 4 feet. When asked for permission to site a gage on their property, most individuals, businesses, and municipalities were extremely receptive. During late September and early October 1989, the entire 25-gage network was installed.

Over the years, some of the gages have been relocated. Re-siting a gage within the highly urbanized areas of Chicago is challenging. New gage locations are researched using satellite imagery to identify and measure distances to possible obstructions. After a selection of alternate sites are chosen, the landowners are contacted and the sites are visited. Careful consideration and every effort are taken to find a new site close to the original grid location, maintaining the 5- to 7-mile grid spacing between gages.

APPENDIX III: RAINGAGE SITE DESCRIPTIONS

This appendix contains site descriptions of the 25 raingage locations (Figure 1) in the network as of September 30, 2018. Sites that have been relocated since the network began operation in October 1989 are noted in the "Placement" section of the descriptions. Note that there are slight differences in latitude and longitude values from previous years. More accurate GPS readings were obtained for all sites during the summer of 2015. GPS readings were also recorded when a site was surveyed or relocated.

During WY2018, five gages were moved to new locations. In the site descriptions, two are listed for each moved gage (WY2018): one for the old (closed) location and one for the new location.

On October 30, 2017, site #10 (Chicago) was moved to near the intersection of S. Halsted St. and W. Cermak Rd. and site #16 (Palos Park) was moved to Swallow Cliff Woods North Forest Preserve. Site #13 was moved on November 29, 2017 to the Chicago Police Department on W. Halsted St. and W. 79th Street. Site #7 (Chicago) was moved on June 20, 2018 to near the intersection of N. Kenmore Ave. and W. Buena Ave. Lastly, site #4 (Skokie) was moved on July 30, 2018 to near the intersection of Howard St. and Hamlin Ave.

Explanation of WY2018 Gage Relocations

Site #4: Extensive construction by a new landowner was planned on property starting on August 1, 2018. The gage was moved about 1.87 miles to the east-southeast on July 30 to a new, temporary location near the intersection of Howard Street and Hamlin Avenue in Skokie, IL.

Site #7: On June 20, 2018, gage #7 was moved about 1.27 miles to the north-northwest to improve precipitation catchment. The new site is in a service area of the Graceland Cemetery and Arboretum near the intersection of N. Kenmore Ave. and W. Buena Ave.

Site #10: To improve precipitation catchment, gage #10 was moved about 0.55 miles to the northwest. The gage is located on a grassy area in the corner of an industrial property near the intersection of S. Halsted St. and W. Cermak Rd.

Site #13: To improve staff safety and precipitation catchment, gage #13 was moved about 0.5 miles to the north. The new site is between the parking lot and building of the Chicago Police Department 6th District in Gresham.

Site #16: To improve precipitation catchment, gage #16 was moved about 1.25 miles to the north-northeast. The new site is near a prairie area, a bat house, and a service area for the Swallow Cliff Woods (Stairs) North County Park.

SITE DESCRIPTION		
Site Number: 1		
County: Cook	Township: 42N	Range: 12E
Section: 20	Lat/Long: 42°06'39.25" / -87°52'05.5"	Quadrangle: Park Ridge
Property Owner: Mission Brook Sanitary District, Attn: John Tomaras		
Address: P.O. Box 2362, Northbrook, Illinois 60065		
Telephone: 847/ 272-2956		
Permission Date: September 14, 1989		
Installation Date: September 27, 1989		
Gage Mfrs. No.: 4669	Gage ID No.: 6561	
<p>Placement: On 6-26-99, moved 20 feet north of previous location, which was about 20 feet northwest of pump station at southwest corner of Post and Cornflower Streets. Previously located in southeast corner of pump station lawn through 5-5-97. Tri-State Tollway is just to the west. Enter area from west at Landwehr Road (north of Willow Road) at Sunset Ridge.</p>		

SITE DESCRIPTION		
Site Number: 2		
County: Cook	Township: 42N	Range: 13E
Section: 19	Lat/Long: 42°06'26.5" / -87°45'23.9"	Quadrangle: Park Ridge
Property Owner: Winnetka Park District, Attn: Henry Michna		
Address: 600 Hibbard Rd, Winnetka, Illinois 60093		
Telephone: 847/ 501-2056		
Permission Date: September 14, 1989		
Installation Date: October 3, 1989		
Gage Mfrs. No.: 5939	Gage ID No.: 261	
<p>Placement: On hill created by dredge material from irrigation ponds, 0.25 miles west of previous location, moved 6-8-12. Was between office building and chain-link/woven strip fence on grassy strip, established 9-10-97. Previously located 20 feet west, between building and parking lot (from 7-31-91). Previously located 15 feet southeast in yard (from 10-03-89). On workdays, facility closes at 1600 local time. Enter facility from west off Hibbard Street, north of Willow Road.</p>		

SITE DESCRIPTION		
<u>Site Number:</u> 3		
<u>County:</u> Cook	<u>Township:</u> 41N	<u>Range:</u> 12E
<u>Section:</u> 28	<u>Lat/Long:</u> 42°01'21.0" / -87°52'39.9"	<u>Quadrangle:</u> Arlington Heights
<u>Property Owner:</u> Private Residence		
<u>Address:</u> 1885 Riverview Avenue, Des Plaines, Illinois 60018		
<u>Telephone:</u> 708/ 824-1093		
<u>Permission Date:</u> September 14, 1989		
<u>Installation Date:</u> September 28, 1989		
<u>Gage Mfrs. No.:</u> 5940	<u>Gage ID No.:</u> 5062	
<u>Placement:</u> Northwest corner of the yard by the fence. Enter Riverview Avenue west off Des Plaines River Road.		

SITE DESCRIPTION		
<u>Site Number:</u> 4 REMOVED: July 30, 2018		
<u>County:</u> Cook	<u>Township:</u> 41N	<u>Range:</u> 13 E
<u>Section:</u> 21	<u>Lat/Long:</u> 42°01'39.49 / -87°45'19.33"	<u>Quadrangle:</u> Park Ridge
<u>Property Owner:</u> William Novello		
<u>Address:</u> 8047 Floral Avenue, Skokie, Illinois 60077		
<u>Telephone:</u> 847/ 677-3422		
<u>Permission Date:</u> June 13, 2011		
<u>Installation Date:</u> June 13, 2011 REMOVED: July 30, 2018		
<u>Gage Mfrs. No.:</u> 4710	<u>Gage ID No.:</u> 5040	
<u>Placement:</u> Moved 500 feet northeast to a neighboring backyard, 3 feet west of a fence. Moved 0.5 blocks north to east side of backyard of resident (6-13-11). Was on grassy strip between mailbox and village payment box on east side of Floral Street near parking lot, established late 3-94. From 12-92, on west side of Floral Street, 50 feet west of original position, on a grassy strip on east side of Floral Street, 15 feet southwest of current position. All locations are just north of Oakton Street (across from Village Hall).		

SITE DESCRIPTION		
<u>Site Number:</u> 4 Installed during WY18		
<u>County:</u> Cook	<u>Township:</u> 41N	<u>Range:</u> 13 E
<u>Section:</u> 26	<u>Lat/Long:</u> 42.01793 / -87.7215	<u>Quadrangle:</u> Evanston
<u>Property Owner:</u> The Talking Farm		
<u>Address:</u> 3669 Howard St., Skokie, IL 60076		
<u>Telephone:</u> 847/ 425-5125		
<u>Permission Date:</u> July 27, 2018		
<u>Installation Date:</u> July 30, 2018		
<u>Gage Mfrs. No.:</u> 4710	<u>Gage ID No.:</u> 5040	
<p><u>Placement:</u> Moved 500 feet northeast to a neighboring backyard, 3 feet west of a fence. Moved 0.5 blocks north to east side of backyard of resident (6-13-11). Was on grassy strip between mailbox and village payment box on east side of Floral Street near parking lot, established late 3-94. From 12-92, on west side of Floral Street, 50 feet west of original position, on a grassy strip on east side of Floral Street, 15 feet southwest of current position. All locations are just north of Oakton Street (across from Village Hall). On 7-30-18 moved gage to The Talking Farm near Howard Street and Hamlin Avenue in Skokie. Gage located next to a raised garden bed.</p>		

SITE DESCRIPTION		
<u>Site Number:</u> 5		
<u>County:</u> Cook	<u>Township:</u> 40N	<u>Range:</u> 12E
<u>Section:</u> 28	<u>Lat/Long:</u> 41°55'55.3" / -87°52'41.3"	<u>Quadrangle:</u> Elmhurst
<u>Property Owner:</u> Private Residence		
<u>Address:</u> 2925 North Sarah St., Franklin Park, Illinois 60131		
<u>Telephone:</u> 708/ 455-2630		
<u>Permission Date:</u> September 13, 1989		
<u>Installation Date:</u> September 28, 1989		
<u>Gage Mfrs. No.:</u> 2267	<u>Gage ID No.:</u> 5105	
<p><u>Placement:</u> Northeast corner of backyard near a fence and a hedge. Enter Schiller Avenue east off Mannheim Road, then south on Sarah Drive (one-way). Alley access is also available in the back.</p>		

SITE DESCRIPTION		
<u>Site Number:</u> 6		
<u>County:</u> Cook	<u>Township:</u> 40N	<u>Range:</u> 13E
<u>Section:</u> 32	<u>Lat/Long:</u> 41.914722° / -87.770639°	<u>Quadrangle:</u> River Forest
<u>Property Owner:</u> Chicago Laborers Training Facility		
<u>Address:</u> 5700 W. Homer Street, Chicago, IL 60639		
<u>Telephone:</u> 773/ 413-3315		
<u>Permission Date:</u> September 13, 2017		
<u>Installation Date:</u> September 13, 2017		
<u>Gage Mfrs. No.:</u> 4738	<u>Gage ID No.:</u> 5304	
<p><u>Placement:</u> On 9-13-17, gage moved about 0.5 miles at a heading of 253 degrees. New location on south side of southern berm of the Chicago Laborers Training Facility complex and on east side access driveway at break in berm. From 9-25-13 to 9-13-17, Site moved about 2 miles southeast to a small yard, along 6 feet north of a 6-foot fence, 10 feet south of 35-foot building on 9-25-13. From 10-2-11 to 8-15-13, in grassy area with 15-foot trees at 30 feet away, at the Chicago Paper and Tube Company. From 7-12-93 to 10-2-11, on the west edge of a backyard 4 feet south of a one-story garage, 15 feet south of a two-story house, and 7 feet northwest of a two-story wooden stairwell/deck. Original location was about 60 feet east-southeast from 9-28-89 through 7-06-93. Chain-link fence. Moved 2 miles northwest to Chicago Paper and Tube Co. on Normandy Ave.</p>		

SITE DESCRIPTION		
<u>Site Number:</u> 7 REMOVED: June 20, 2018		
<u>County:</u> Cook	<u>Township:</u> 40N	<u>Range:</u> 14E
<u>Section:</u> 21	<u>Lat/Long:</u> 41°56'35.89" / -87°38'42.3"	<u>Quadrangle:</u> Chicago Loop
<u>Property Owner:</u> Broadway United Methodist Church, Attn: Alexis Rivera, Office Manager		
<u>Address:</u> 3338 North Broadway, Chicago, Illinois 60657		
<u>Telephone:</u> 773/ 348-2679		
<u>Permission Date:</u> October 4, 1991		
<u>Installation Date:</u> October 4, 1991 REMOVED: June 20, 2018		
<u>Gage Mfrs. No.:</u> 5296	<u>Gage ID No.:</u> 5303	
<p><u>Placement:</u> Just northeast of parking lot in grass strip between lot and black wrought iron fence. Enter parking lot from Buckingham Place (one-way westbound from Broadway). Was located at Belmont Harbor boat landing (10-01-89 through 12-27-89), on the Lincoln Park Gun Club roof (12-27-89 through 06-28-91), and just north of Diversey Harbor in a playground (6-28-91 through 10-04-91).</p>		

SITE DESCRIPTION		
Site Number: 7 Installed during WY18		
<u>County:</u> Cook	<u>Township:</u> 40N	<u>Range:</u> 14E
<u>Section:</u> 17	<u>Lat/Long:</u> 41.958972 / -87.657361	<u>Quadrangle:</u> Chicago Loop
<u>Property Owner:</u> Graceland Cemetery and Arboretum		
<u>Address:</u> 4001 N. Clark St., Chicago, Illinois 60613		
<u>Telephone:</u> 773/ 525-1105		
<u>Permission Date:</u> May 25, 2018		
<u>Installation Date:</u> June 20, 2018		
<u>Gage Mfrs. No.:</u> 5296	<u>Gage ID No.:</u> 5303	
<u>Placement:</u> (06-20-18) gage was moved 1.27 miles north-northwest to a non-public service area of the Graceland Cemetery and Arboretum. Was located at Belmont Harbor boat landing (10-01-89 through 12-27-89), on the Lincoln Park Gun Club roof (12-27-89 through 06-28-91), just north of Diversey Harbor in a playground (6-28-91 through 10-04-91), and on grass strip/iron fence at Broadway United Methodist Church (10-04-91 through 06-20-18).		

SITE DESCRIPTION		
<u>Site Number:</u> 8		
<u>County:</u> Cook	<u>Township:</u> 39N	<u>Range:</u> 12E
<u>Section:</u> 29	<u>Lat/Long:</u> 41°50'41.1" / -87°52'55.6"	<u>Quadrangle:</u> Hinsdale
<u>Property Owner:</u> Forest Preserve District of Cook County, Attn: William Granberry		
<u>Address:</u> 2403 Belleview Ave., Westchester, IL 60154		
<u>Telephone:</u> 708/ 771-1059		
<u>Permission Date:</u> September 21, 1989		
<u>Installation Date:</u> September 27, 1989		
<u>Gage Mfrs. No.:</u> 4705	<u>Gage ID No.:</u> 5070	
<u>Placement:</u> Just south of Forest Preserve entrance road, on the west side of Forest Preserve property. Through 12-11-97, 300 feet to east-southeast in southeast corner of backyard between pool and grape hedge. On 5-20-10 moved 3 feet west to sunnier location. Enter Windsor Drive east from Belleview Drive, south from Cermak Road. Just west of Salt Creek and parallel bike trail.		

SITE DESCRIPTION		
<u>Site Number:</u> 9		
<u>County:</u> Cook	<u>Township:</u> 39E	<u>Range:</u> 13E
<u>Section:</u> 28	<u>Lat/Long:</u> 41°51'54.19" / -87°45'16.87"	<u>Quadrangle:</u> Oak Park
<u>Property Owner:</u> Mr. Lido Manetti, Water Department Director, City of Cicero		
<u>Address:</u> Roosevelt and Laramie, Cicero, IL 60804		
<u>Telephone:</u> 708/ 656-3600 Ext. 164		
<u>Permission Date:</u> March 14, 2011		
<u>Installation Date:</u> March 14, 2011		
<u>Gage Mfrs. No.:</u> 5303	<u>Gage ID No.:</u> 6559	
<p><u>Placement:</u> Returned to Cicero Water Station (Laramie) in southeast corner of lot (3-14-11). Moved 1.5 miles northeast of previous location to Columbia Park Golf Course to 10 feet south of one-story shed on east border of driving range, 8-11-08. Moved 2 miles west to backyard of residence, 10 feet west of 1.5-story house and 30 feet east of one-story garage, 9-18-05. Was at Cicero Water Station on Roosevelt Drive, 0.5 miles east of previous location, in center of 50- by 100-foot grassy lot, 50 feet west of 20-foot water tank (6-7-02). Was at Cicero Water Station 1.3 miles (Roosevelt and Laramie) north of previous location (through 7-1-01). Was on southwest corner of schoolyard, 12 feet from south fence line and along west fence, west of the nunnery (through 4-9-98). Was located at 5530 West 24th Street (9-28-89 through 5-24-89).</p>		

SITE DESCRIPTION		
<u>Site Number:</u> 10 REMOVED: October 30, 2017		
<u>County:</u> Cook	<u>Township:</u> 39N	<u>Range:</u> 14E
<u>Section:</u> 28	<u>Lat/Long:</u> 41°50'42.5" / -87°38'28.1"	<u>Quadrangle:</u> Englewood
<u>Property Owner:</u> Rental Residence		
<u>Address:</u> 527 West 26th Street, Chicago, Illinois 60616		
<u>Telephone:</u> 312/ 225-8066		
<u>Permission Date:</u> September 13, 1989		
<u>Installation Date:</u> September 28, 1989 REMOVED: October 30, 2017		
<u>Gage Mfrs. No.:</u> 3342	<u>Gage ID No.:</u> 5113	
<p><u>Placement:</u> Backyard near edge of walk north of a garage and was east of a spruce tree (removed in 2004). Enter off alley south of 26th Street, where locked gate is to be entered (observer keeps key). In Chinatown area, block between Wallace and Normal.</p>		

SITE DESCRIPTION		
Site Number: 10 Installed during WY18		
County: Cook	Township: 39N	Range: 14E
Section: 29	Lat/Long: 41.850769 / -87.648333	Quadrangle: Englewood
Property Owner: Chicago Scenic Studios		
Address: 955 W. Cermak Rd., Chicago, Illinois 60608		
Telephone: 312/ 274-9900		
Permission Date: October 29, 2017		
Installation Date: October 30, 2017		
Gage Mfrs. No.: 3342	Gage ID No.: 5113	
Placement: 0.55 miles to the northwest from previous location. The gage is located on a grassy area in the corner of an industrial property. Previously in Chinatown residential backyard, block between Wallace and Normal (09-28-89 through 10-30-18)		

SITE DESCRIPTION		
Site Number: 11		
County: Cook	Township: 38N	Range: 12E
Section: 28	Lat/Long: 41°45'31.8" / -87°53'20.2"	Quadrangle: Berwyn
Property Owner: Edgewood Valley Country Club, Attn: Ronald B. McCarthy, Superintendent		
Address: 7500 S. Willow Springs Road, LaGrange, Illinois 60525		
Telephone: 708/ 246-2800		
Permission Date: April 18, 2002		
Installation Date: April 18, 2002		
Gage Mfrs. No.: 5947	Gage ID No.: 4452	
Placement: Moved 0.25 miles to Edgewood Country Club (4-18-02). Site on north end at highest elevation of golf course, about 60 feet from fence line separating the club from the 294 Tollway. Was in center of backyard near edge of large garden, accessed from Willow Springs Road, south of Joliet Road on parcel of land between Interstate-55 and Tri-State Tollway.		

SITE DESCRIPTION		
<u>Site Number:</u> 12		
<u>County:</u> Cook	<u>Township:</u> 38N	<u>Range:</u> 13E
<u>Section:</u> 28	<u>Lat/Long:</u> 41.757833° / -87.768167°	<u>Quadrangle:</u> Berwyn
<u>Property Owner:</u> HallStar, Attn: Dan Fitzzgerald		
<u>Address:</u> 5851 West 73rd Street, Bedford Park, Illinois 60638		
<u>Telephone:</u> 708/ 594-5063		
<u>Permission Date:</u> November 24, 1992		
<u>Installation Date:</u> June 14, 2017		
<u>Gage Mfrs. No.:</u> 5985	<u>Gage ID No.:</u> 5111	
<p><u>Placement:</u> On 6-14-17, moved gage about 300 feet at heading of 168 degrees east of north to grass between and south of concrete pad and storm retention basin. Previous location was on a small incline close to a 6-foot chain-link security fence from 9-11-97 through 6-14-2017. Previously 10 feet to northeast along same service drive in mowed grassy area (9-17-93 through 9-11-97). Previously about 400–500 feet to the northeast in a large grassy area north of office building (11-24-92 through 5-17-93). Prior to 11-24-92, gage was at Reckitt and Coleman about 0.9 miles east of present location.</p>		

SITE DESCRIPTION		
<u>Site Number:</u> 13 REMOVED: November 11, 2017		
<u>County:</u> Cook	<u>Township:</u> 38N	<u>Range:</u> 14E
<u>Section:</u> 28	<u>Lat/Long:</u> 41°45'30.1" / -87°38'29.9"	<u>Quadrangle:</u> Englewood
<u>Property Owner:</u> Greune Coal Company, Attn: Paul Schoeing		
<u>Address:</u> 7435 South Union Ave., Chicago, Illinois 60621		
<u>Telephone:</u> 773/ 846-4000		
<u>Permission Date:</u> March 1, 1995		
<u>Installation Date:</u> March 15, 1995 REMOVED: November 11, 2017		
<u>Gage Mfrs. No.:</u> 3771	<u>Gage ID No.:</u> 5058	
<p><u>Placement:</u> It is currently placed on top of a 6-foot dividing wall. Was about 7 feet from the 10-foot wall and 30 feet from the 25-foot-tall elevated-train retaining wall (05-03-99). In southwest corner of property north of an elevated railroad track and east of a concrete barrier. Access is from south on Union Street (one-way north) north of 76th Street. Location is about four blocks due west of original position (09-29-89 to 03-15-95) in Mrs. Wolfe's yard.</p>		

SITE DESCRIPTION		
<u>Site Number:</u> 13 Installed during WY18		
<u>County:</u> Cook	<u>Township:</u> 38N	<u>Range:</u> 14E
<u>Section:</u> 28	<u>Lat/Long:</u> 41.751511 / -87.6442	<u>Quadrangle:</u> Englewood
<u>Property Owner:</u> City of Chicago Police Department		
<u>Address:</u> 7808 S. Halsted St., Chicago, Illinois 60621		
<u>Telephone:</u> 312/ 745-3628		
<u>Permission Date:</u> October 4, 2017		
<u>Installation Date:</u> October 30, 2017		
<u>Gage Mfrs. No.:</u> 3771	<u>Gage ID No.:</u> 5058	
<u>Placement:</u> About 0.5 miles south of previous location. Gage located in flowerbed between the police parking lot and building of District 6 Chicago Police Department. Original position (09-29-89 to 03-15-95) in Mrs. Wolfe's yard, then about four blocks due west in Greune Coal Company coal yard (03-15-95 through 10-30-17) mounted on top of a 6-foot dividing wall and other various locations within the coal yard.		

SITE DESCRIPTION		
<u>Site Number:</u> 14		
<u>County:</u> Cook	<u>Township:</u> 38N	<u>Range:</u> 15E
<u>Section:</u> 29	<u>Lat/Long:</u> 41°45'27.2" / -87°32'37.9"	<u>Quadrangle:</u> Jackson Park
<u>Property Owner:</u> City of Chicago - South Water Purification Plant, Attn: Chief Engineer, Diane Cardella, Assistant Chief Filtration Engineer		
<u>Address:</u> 3300 East Cheltenham Place, Chicago, Illinois 60649		
<u>Telephone:</u> 312/ 747-0382		
<u>Permission Date:</u> September 12, 1989		
<u>Installation Date:</u> September 28, 1989		
<u>Gage Mfrs. No.:</u> 2000	<u>Gage ID No.:</u> 4453	
<u>Placement:</u> Snow shield installed, 10-9-96. Center of large grassy area (turf-covered roof) over sand filtration beds. Two distant buildings are east and west of the site. Enter facility east off 79th Street from South Shore Drive.		

SITE DESCRIPTION		
<u>Site Number:</u> 15		
<u>County:</u> Cook	<u>Township:</u> 37N	<u>Range:</u> 11E
<u>Section:</u> 20	<u>Lat/Long:</u> 41°40'45.9" / -87°57'54.4"	<u>Quadrangle:</u> Sag Bridge
<u>Property Owner:</u> St. Mary's Seminary, c/o Fr. Vendelin		
<u>Address:</u> 14246 Main Street, P.O. Box 608, Lemont, Illinois 60439		
<u>Telephone:</u> 630/ 257-2494		
<u>Permission Date:</u> November 11, 1994		
<u>Installation Date:</u> November 22, 1994		
<u>Gage Mfrs. No.:</u> 5935	<u>Gage ID No.:</u> 4421	
<u>Placement:</u> About 250 feet along west side of a lane that extends southeasterly from the main building and drive-around, in a clearing. Previous original position (09-27-89 to 11-22-94) was at the MWRDGC site in downtown Lemont about 1.5 miles west of present position. Entrance lane is south off Main Street. Exit Interstate-55 south on Lemont Road to downtown, then proceed east on Main Street.		

SITE DESCRIPTION		
<u>Site Number:</u> 16 REMOVED: October 30, 2017		
<u>County:</u> Cook	<u>Township:</u> 37N	<u>Range:</u> 12E
<u>Section:</u> 28	<u>Lat/Long:</u> 41°39'47.4" / -87°52'13.5"	<u>Quadrangle:</u> Palos Park
<u>Property Owner:</u> Private Residence		
<u>Address:</u> 240 Timber Edge Lane, Palos Park, Illinois 60464		
<u>Telephone:</u> 708/ 361-0853		
<u>Permission Date:</u> September 11, 1989		
<u>Installation Date:</u> September 27, 1989 REMOVED: October 30, 2017		
<u>Gage Mfrs. No.:</u> 5283	<u>Gage ID No.:</u> 5022	
<u>Placement:</u> Along west edge of lawn in backyard, about 20 feet south of property line and utility. Was moved about 2 feet on 4-26-91 to facilitate landscaping. Enter subdivision from 125th Street (off Route 45), just south of McCarthy Road. West-southwest of Papoose Lake.		

SITE DESCRIPTION		
<u>Site Number:</u> 16 Installed during WY2018		
<u>County:</u> Cook	<u>Township:</u> 37N	<u>Range:</u> 12E
<u>Section:</u> 21	<u>Lat/Long:</u> 41.680238 / -87.861667	<u>Quadrangle:</u> Palos Park
<u>Property Owner:</u> Swallow Cliff Stairs Forest Preserve: Cook County		
<u>Address:</u> Sag Valley Trail, near Calumet Sag Road and Route 45, Palos Park, Illinois 60464		
<u>Telephone:</u> 708/ 771-1008		
<u>Permission Date:</u> October 25, 2017		
<u>Installation Date:</u> October 30, 2017		
<u>Gage Mfrs. No.:</u> 5283	<u>Gage ID No.:</u> 5022	
<u>Placement:</u> About 1.25 miles to the north-northeast of previous location. The new site is near a small prairie patch, a bat house, and a service area for the Swallow Cliff Stairs, County Park. Original site (09-27-89 through 10-30-17) on west edge of lawn in backyard, about 20 feet south of property line and utility, 240 Timber Edge Lane, Palos Park, Illinois 60464		

SITE DESCRIPTION		
<u>Site Number:</u> 17		
<u>County:</u> Cook	<u>Township:</u> 37N	<u>Range:</u> 13E
<u>Section:</u> 28	<u>Lat/Long:</u> 41°40'30.1" / -87°45'00.0"	<u>Quadrangle:</u> Palos Park
<u>Property Owner:</u> Alsip Fire Department Station #2, Attn: Lt. John Solum		
<u>Address:</u> 11946 South Laramie Street, Alsip, Illinois 60482		
<u>Telephone:</u> 708/ 385-6902		
<u>Permission Date:</u> August 9, 1994		
<u>Installation Date:</u> August 9, 1994		
<u>Gage Mfrs. No.:</u> 5284	<u>Gage ID No.:</u> 5415	
<u>Placement:</u> Just north of parking lot west of (behind) Alsip Fire Department Station #2 building. Present location is about 150 yards south-southeast of previous original position (9-27-89 to 08-09-94) at Sardee Industries. Enter Laramie Street north from 122nd Street, west of Cicero Avenue. Northeast of Tri-State Tollway, south of Restvale Cemetery.		

SITE DESCRIPTION		
<u>Site Number:</u> 18		
<u>County:</u> Cook	<u>Township:</u> 37N	<u>Range:</u> 14E
<u>Section:</u> 29	<u>Lat/Long:</u> 41°40'40.9" / -87°39'04.4"	<u>Quadrangle:</u> Blue Island
<u>Property Owner:</u> AxleTech International, Attn: Mr. Mike Newman		
<u>Address:</u> 1120 W 119 th St., Chicago, Illinois 60643		
<u>Telephone:</u> 773/ 396-5639, (Denene Roberts)		
<u>Permission Date:</u> March 5, 2003		
<u>Installation Date:</u> March 5, 2003		
<u>Gage Mfrs. No.:</u> 5279	<u>Gage ID No.:</u> None	
<p><u>Placement:</u> Moved about 600 feet north-northeast to Heat Treat at 1120 West 119th St. and is in the center of a fenced area south of employee parking, from old location at Ingersol, on 3-6-03. Was at west end of property just northwest of a truck scale and east of property fence. Gage moved about 150 feet north of original position, within same property, on 8-09-94.</p>		

SITE DESCRIPTION		
<u>Site Number:</u> 19		
<u>County:</u> Cook	<u>Township:</u> 37N	<u>Range:</u> 15E
<u>Section:</u> 20	<u>Lat/Long:</u> 41°40'44.39" / -87°32'23.00"	<u>Quadrangle:</u> Lake Calumet
<u>Property Owner:</u> Gallo Equipment, Robert Gallo		
<u>Address:</u> 11835 South Avenue O, Chicago, Illinois 60633		
<u>Telephone:</u> 773/ 374- 5515		
<u>Permission Date:</u> June 30, 2011		
<u>Installation Date:</u> July 14, 2011		
<u>Gage Mfrs. No.:</u> 4718	<u>Gage ID No.:</u> 5291	
<p><u>Placement:</u> Located 0.45 miles north of previous location, 7-14-11. Was in grassy area just north of a shop building and just south of entrance drive, established on 11-24-92. Previous original position was 50 feet due east in a grassy area just south of entrance drive and just west of the main parking lot. A factory building is located 50 feet north-northeast of both locations.</p>		

SITE DESCRIPTION		
<u>Site Number:</u> 20		
<u>County:</u> Cook	<u>Township:</u> 36N	<u>Range:</u> 12E
<u>Section:</u> 29	<u>Lat/Long:</u> 41°35'12.3" / -87°52'33"	<u>Quadrangle:</u> Mokena
<u>Property Owner:</u> Panduit Corporation, c/o Marty Cullen, Manager, Plant Engineering & Maintenance		
<u>Address:</u> 10600 167 th , Orland Park, Illinois 60447-3091		
<u>Telephone:</u> 708/ 532-1800, ext. 1279		
<u>Permission Date:</u> May 1, 2008		
<u>Installation Date:</u> May 1, 2008		
<u>Gage Mfrs. No.:</u> 5280	<u>Gage ID No.:</u> 5061	
<u>Placement:</u> On 5-1-08, moved gage to Panduit Corporation property (10600 167 th , Orland Park), about 600 feet to the north-northwest of old location. Site is along fence line of the western border of property. Previous location was about 30 feet east of welding shop on rural property. Shop was east building of home/shop complex. Four dachshunds outside. Was located about 0.25 miles southeast on South 104th Avenue (9-26-89 through 3-16-90).		

SITE DESCRIPTION		
<u>Site Number:</u> 21		
<u>County:</u> Cook	<u>Township:</u> 36N	<u>Range:</u> 13E
<u>Section:</u> 28	<u>Lat/Long:</u> 41°35'12.5" / -87°44'54.7"	<u>Quadrangle:</u> Harvey
<u>Property Owner:</u> Private Residence		
<u>Address:</u> 16710 Lockwood Ave., Tinley Park, Illinois 60477		
<u>Telephone:</u> 708/ 560-0213		
<u>Permission Date:</u> September 16, 1989		
<u>Installation Date:</u> September 28, 1989		
<u>Gage Mfrs. No.:</u> 4692	<u>Gage ID No.:</u> 5037	
<u>Placement:</u> North end of backyard west of (behind) garage. Enter Lockwood Road south off 167th Street.		

SITE DESCRIPTION		
Site Number: 22		
County: Cook	Township: 36N	Range: 14E
Section: 21	Lat/Long: 41°35'08.4" / -87°38'00.9"	Quadrangle: Harvey
Property Owner: U.S. Army Reserve Training Center, Attn: LTC Robert Goulke		
Address: 400 East 167th Street, Harvey, Illinois 60426		
Telephone: 708/ 339-0001		
Permission Date: September 12, 1989		
Installation Date: September 26, 1989		
Gage Mfrs. No.: 5286	Gage ID No.: 5035	
<p>Placement: Between parking lot and reserve building, just north of fenced-in reserve storage lot, about 150 feet south of 167th Street. Was located about 100 feet northwest on Army property, just west of parking lot before a building was constructed on property just to the west (9-26-89 through 11-02-90). Enter 167th Street east off Halsted Avenue.</p>		

SITE DESCRIPTION		
Site Number: 23		
County: Cook	Township: 36N	Range: 15E
Section: 29	Lat/Long: 41°35'16.0" / -87°32'50.1"	Quadrangle: Calumet City
Property Owner: Lansing Police Department, Attn: Commander Charles Maricich		
Address: 2710 170 th Street, Lansing, Illinois 60438-1110		
Telephone: 708/ 895-7128		
Permission Date: April 30, 1998		
Installation Date: April 30, 1998		
Gage Mfrs. No.: 4723	Gage ID No.: 5043	
<p>Placement: Moved about 0.5 miles west to a well-exposed location on the property of the Lansing Police Department on 4-30-98. Was east of garage/shed, between two trees (5-96 to 4-98). Was about 150 feet north, 6 feet from east fence in northeast corner of storage yard of Public Works complex, about 75 feet east of the same recycling building (9-89 to 5-96).</p>		

SITE DESCRIPTION		
Site Number: 24		
County: Cook	Township: 35N	Range: 13E
Section: 16	Lat/Long: 41°31'04.4" / -87°43'58.5"	Quadrangle: Harvey
Property Owner: Village of Matteson, Attn: Frank W. Denman		
Address: 20500 S. Cicero Ave., Matteson, Illinois 60443		
Telephone: 708/ 748-1411		
Permission Date: September 12, 1989		
Installation Date: September 26, 1989		
Gage Mfrs. No.: 4687	Gage ID No.: WMU81122	
<p>Placement: Site moved 30 feet to the west, about 50 feet away from two 20-foot trees, one to the southwest and one to the southeast, about 30 feet away from a newly dug trench and building site (5-7-99). 5 feet west of telephone terminal box, on grass, north of parking lot and northeast of Matteson Police Department on Cicero Avenue, 0.5 miles north of U.S. 30.</p>		

SITE DESCRIPTION		
Site Number: 25		
County: Cook	Township: 35N	Range: 14E
Section: 13	Lat/Long: 41°31'14.3" / -87°34'28.95"	Quadrangle: Calumet City
Property Owner: Big John's Farm Stand, Attn: John DeBoer		
Address: 1754 East Joe Orr Road, Chicago Heights, Illinois 60411		
Telephone: 708/ 758-2711		
Permission Date: September 12, 1989		
Installation Date: September 26, 1989		
Gage Mfrs. No.: 4661	Gage ID No.: WMU80955	
<p>Placement: Originally northeast of farm stand parking lot, northwest of house and northeast of farm stand. Small ditch between parking lot and gage, with large trees near house. On 5-20-10, moved west 330 feet to more open, less trafficked area. Just east of Interstate 394 and Stony Island Avenue, and west of Torrence Avenue.</p>		

APPENDIX IV: HISTORICAL NETWORK OPERATION AND MAINTENANCE³

First Generation Raingages 1989 through 2001

In 1989, the ISWS provided all of the raingages from its inventory. Each universal weighing-bucket gage (Belfort brand) used throughout the network was fitted with a battery-powered chart drive that rotated the 24-hour charts approximately once per day. To improve the accuracy and reliability of the gages, as of February 1, 2001, the 25 gages were redeployed, fitted with linear potentiometers and data loggers, in addition to the battery-powered chart drive. The chart drive was altered to use eight-day charts instead of 24-hour charts to accommodate monthly instead of weekly servicing. During WY 2010, the 25 gages were again upgraded and redeployed with a new data logger and cell modem, powered by a 12-volt battery and solar panel to obtain data in real time. This allowed access to provisional real-time precipitation. A website was created to post the provisional data on the internet. Three days of 10-minute data and two weeks of hourly data are now available online, <http://www.isws.illinois.edu/data/ccprecipnet/livedata.asp>.

The weighing-bucket recording gages used are as reliable as any others available (see Jones, 1969, for a description of tests of different raingages). All raingages are subject to catchment errors due to wind, wetting losses, evaporation, splashing into or out of the gage, and blowing snow (Legates and Willmott, 1990). Koschmieder (1934) noted that as wind speed increases, gage catch decreases. Legates and Willmott (1990) found that gage errors "tend to be proportional to total precipitation and amount to nearly 11 percent of the catch." To prevent loss from blowing snow during the winter, the Nipher shield and the shield used by Lindroth (1991) are helpful but were not considered for the new network because of cost and vandalism considerations. In October 1996, an Alter shield was installed at site #14, a very windy lakefront location.

The first generation of the 25-raingage network was used from October 1989 to February 2001. This setup used the Belfort gage as it was originally designed. This design used a galvanized bucket that held 12 inches of precipitation calibrated to an 8-inch collection orifice opening, with data recorded on charts. The charts measured up to 12 inches of precipitation. The upward pen traverse on a chart measured the first 6 inches the bucket caught, and a reversed, downward pen traverse measured inches 7–12. Use of the latter traverse occurred infrequently but was vital whenever more than 6 inches of precipitation occurred between chart periods or during winter when the antifreeze-charged buckets accumulated precipitation for long periods. This generation of gages used a battery-operated clock to rotate a 24-hour chart. The time on the charts was set by the observer's watch to CST. Charts were collected and sent to ISWS weekly by David and Dorothy Rosenberg, and then edited and digitized at the ISWS.

3: Historical information has been included in this report as required by the sponsor. Appendix III content was reproduced from Bauer, 2018 and updated for WY2018.

Second Generation Raingages 2001 through 2010

The second generation of gages was used from February 2001 through September 2010. Each gage was fitted with a linear potentiometer to convert the weight of the water into a corresponding voltage and a TattleTale-8 data logger (Onset Computer Corp., Cape Cod, MA) that used eight AA batteries for power. The 24-hour gear set was replaced with 8-day chart cylinder gears that rotated the chart cylinder approximately once per week. The timing resolution of the charts was somewhat reduced, but still adequate for hourly measurements, and the rainfall accuracy for the 8-day charts was comparable to the 24-hour charts (Westcott, 2002). The change in clock gears allowed the ISWS technician to change the charts monthly when data were collected from the data loggers. The data loggers recorded the date, time (CST), and an accumulated precipitation total every 10 minutes. The data were downloaded to a laptop computer during the first week of each month for processing and quality control. The time on the data loggers was set using the laptop clock. The charts were digitized for all gages through WY 2008 and only for individual gages with questionable digital data in WYs 2009 and 2010.

A test bed of reserve gages was set up at the ISWS in fall 2006 and moved to the nearby ISWS Bondville Site in 2011. Daily data from these gages are compared with the National Oceanic and Atmospheric Administration (NOAA) gages and the Illinois Climate Network gage at the same site. Gages in the network that have suspicious data are replaced with one of these reserve gages that compares well with the NOAA Cooperative gage. During 2010, all 25 gages were replaced with those that had been compared with a NOAA standard gage and were subjected to a laboratory drip test. In addition, during the warm season when temperatures are above freezing and antifreeze is not needed, we began to weigh the water in the gages (at ISWS and in Cook County), convert that amount to inches, and compare it with the amount of rain recorded by the data logger. This has bolstered our confidence in the raingage calibrations and gage totals.

Third Generation Raingages 2010 through 2018

In 2010, the third generation of refurbished weighing-bucket Belfort gages was installed in the network, replacing the TattleTale-8 data loggers and chart drives with Campbell CR200 data loggers (Campbell Scientific Inc., Logan, Utah) and cell modems. This model of data logger has non-volatile memory. If the power is lost to the logger, the time, date, program, and 10-minute precipitation and battery voltage are stored in memory. When power is restored to a data logger, it will return to operating condition. The data are transmitted to an ISWS computer on an hourly basis and are stored on the Campbell data logger. The new data loggers and modems are powered by a 12-volt absorbent glass mat (agm) battery with solar recharge. Data loggers are programmed to activate the modem at the top of the hour only if the battery has 12-volts or more of power, so that if the battery drops below this threshold, it is still able to power the data logger. A computer at the ISWS is programmed to retrieve the data at the top of the hour and append the data to an existing file. This file is then displayed online. If a battery at a specific site falls below 12 volts, the data are retrieved when the battery charge is restored to above threshold values by either solar energy or manually by changing the battery with a fully charged battery.

Using 7-watt flex solar panels and dipole or omni antennas, most gage sites have sufficient solar exposure and cell phone coverage to transmit hourly. The gage at site 7, while having strong cell phone coverage, sends data only at midnight as wireless usage in the area seems to prohibit routine hourly transmission. Rigid 10-watt solar panels have been connected to nine gages (3, 4, 7, 8, 10, 12, 15, 19, and 21) to obtain adequate solar exposure for power generation during the winter, minimizing the need to download data manually. Wilson antennas were installed at a number of gages to provide for more reliable data transmission (2, 3, 5, 7, 8, 10, 14, 15, 21, and 25), an omni antenna at 4, 17, 18, and 22, and dipole antennas at the remaining sites. A PolyPhaser in-line surge filter has been added to most Wilson antennas to reduce susceptibility to electrical surges. A grounding rod has been added to most gages. The new gage system precludes the necessity of chart drives, and thus all were removed from the refurbished gages in 2010.

Up until the 2010 launch of the real-time data transmission, a raingage technician residing in Champaign, Illinois, traveled to Cook County and serviced each gage during the first week of each month. Servicing included downloading data from data loggers, recalibrating the gage, emptying the bucket, and noting any problems, including gage imbalance or instability, data logger malfunction, vandalism, or unauthorized movement of the gage. Now, travel to the network occurs only when necessary, such as when the buckets are becoming full, when batteries need to be replaced, when a gage appears to malfunction, when we are informed of vandalism by the gage site property owners or managers, and for twice-yearly servicing that includes calibration and either adding or removing antifreeze. At the beginning of the cold season (November–March), a 1-liter charge of antifreeze with an anti-evaporation suppressant is added to each bucket. Antifreeze causes frozen precipitation to melt in the bucket as it is caught, allowing the weighing mechanism to give a proper reading. Plastic buckets are now used to avoid issues with seam failure and for easier cleaning and are emptied and recharged with antifreeze when needed.

APPENDIX V: INSTRUCTIONS FOR RAINGAGE TECHNICIANS

1. Supplies required for proper servicing of the instruments in the Cook County raingage network:

- Spare Campbell CR200 data logger
- Spare modem
- Spare antenna
- Spare null modem cable
- Spare 12-volt agm rechargeable batteries
- Spare data logger
- Roll of paper towels or similar absorbent material
- Ball-point pen or pencil
- Grass clippers and/or sickle
- Spare ant traps
- Clipboard
- Spare 12-quart bucket
- Set of weights for calibration
- Laptop computer and an a/c adapter

2. Make sure time is in the Central Standard Time zone:

Data logger time is coordinated with the computer collecting the data. The time is checked at midnight and is allowed a 1-second deviation.

3. Order of servicing upon arrival at a site:

1) Cut the grass around the raingage if necessary or applicable. Do this to the specifications of the landowner or below the level of the gage door, whichever is shorter.

2) Remove the collector assembly (top cap) from the top of the gage by rotating the collector assembly clockwise to disengage the tongue-and-groove assembly, set it down, and then carefully lift the bucket off the weighing platform (if there is water in it). Weigh the bucket and collection, empty the bucket, clean with a paper towel, and weigh the empty bucket for a tare. The grams of the collection divided by 823.7 yields the collection present in inches. During wintertime operations when a small amount of antifreeze is in the bucket, do not empty the bucket contents until the data logger passes the 10-inch mark. At that point, pour the bucket contents into a sealed container and dispose of it properly. **DO NOT POUR SOLUTION ONTO THE GROUND!** If wintertime conditions prevail, recharge the empty bucket with 1 liter of antifreeze and evaporation suppressant and weigh the bucket to note the tare weight. During summertime operations, a capful of algaecide (~1 tablespoon) is added to the bucket to prevent algal growth. The bucket is then repositioned on the platform. Reinstall the collector assembly by setting it on top of the raingage casing and turning counterclockwise until the tongue-and-groove assembly is connected. At any time of the year, once the

collector is repositioned, check the gage to make sure the top edge of the collector orifice is level.

3) Wipe the inside base of the gage to keep it relatively clean. Make sure you have removed all supplies and tools from the site before moving on to the next site. Note any serious problems encountered during servicing. Situations worthy of immediate attention include unauthorized movement of the raingage, vandalism, and theft. Make minor repairs (e.g., debris in the collection bucket, replace batteries with charged ones, etc.). Schedule major repairs as soon as possible.

4. Change in site status:

If you become aware that there has been or will be a change of status of one of the sites in the network, or one landowner requests movement of the gage, alert the project director and contact the landowner to work out a new arrangement. It is important to try to keep the sites as permanent as possible during the course of this project.

5. Public relations:

As a representative of the state of Illinois, it is imperative that your contacts with the landowners and others are as cordial as possible and that you respect their property. They are providing an important service by agreeing to have the instrumentation on their property, so please keep their good will. Refer any questions they have that you are unable to answer concerning the project and your job to the project director. Provide them the toll-free number for Erin Bauer, (866) 292-7305, and the website address for real-time provisional precipitation data (<http://www.isws.illinois.edu/data/ccprecipnet/livedata.asp>).

APPENDIX VI: DOCUMENTATION OF RAINGAGE MAINTENANCE⁵

This appendix documents the maintenance work carried out by Champaign-based Illinois State Water Survey staff at each network site from WY1990 through WY2018. Any unusual gage activity performed by non-Water Survey staff is also included. The technician normally relevels the gages and trims vegetation around the gages when required and replaces batteries if necessary, but these tasks are not always noted. Calibration checks, gage-cleaning, and seasonal preparation activities conducted at various times throughout the water year are not always listed here unless some other servicing was required at a particular site. Site visits that only include emptying the collection bucket, clearing vegetation, or cleaning are not listed. Organized chronologically by site number, this documentation is accurate through September 30, 2018.

5: Historical information has been included in this report as required by the sponsor. Appendix V content was reproduced from Bauer, 2018 and updated for WY2018. The site name reflects the gage locations for WY2018. Refer to maintenance logs for locations prior to WY2018.

SITE 1: NORTHBROOK: MISSION BROOK SANITARY DISTRICT

- 10-95: Replaced gage at same location.
- 04-97: Moved gage about 10 feet to the northwest of the pumping station because of bulldozer activity in the property immediately adjacent to previous location.
- 05-08-97: Moved gage about 20 feet to the northwest of the pumping station.
- 09-10-98: Replaced chart drive.
- 06-26-99: After two instances of vandalism, replaced and moved gage about 20 feet to the north so that it is more visible at night. Added lock to gage.
- 02-01-01: Replaced old gage with rebuilt gage with data logger.
- 03-02-01: Replaced potentiometer.
- 08-01-02: Installed redesigned data logger.
- 11-04-04: Replaced gage housing after vandalism. Replaced chart drive. Installed co-located gage and data logger to south of Gage 1.
- 01-01-05: Co-located gage became primary gage. Removed original primary gage.
- 04-06-05: Reinstalled original (02-01-01) primary gage and data logger.
- 04-04-09: Replaced outer shell of the gage.
- 10-02-09: Replaced chart drive.
- 01-17-10: Installed co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.
- 05-20-10: Removed older gage, as both gages reported nearly equal precipitation.
- 05-20-10: Took pictures.
- 07-11-10: Took pictures.
- 09-30-10: Waxed gage inlet.
- 10-21-10: Soldered potentiometer connections. Installed secondary co-located gage with data fed to the primary gage data logger.

10-29/30-10: Took pictures. Installed two new T-bases.

06-13-11: Recalibrated gages.

09-01-11: Grounded logger and modem to base of gage.

03-19-12: Replaced co-located gage.

07-08-12: Added ground rod.

03-30-14: Recalibrated secondary gage.

04-29-15: Relevelled gage.

07-04-15: Reattached disconnected red wire to potentiometer of secondary gage.

08-12-15: Reattached disconnected white wire to potentiometer of secondary gage. Primary gage recalibrated.

12-09-15: Replaced battery.

06-23-16: Recalibrated both gages. Program scan rate changed from 10 sec. to 5 sec. Replaced battery in secondary gage. Ant trap placed in primary gage.

12-06-16: Calibration checked and battery replaced.

04-03-17: Replaced battery and relevelled gage.

06-21-17: Gages calibrated and battery changed.

10-26-17: Replaced battery.

12-11-17: Replaced battery.

05-03-18: Relevelled primary gage.

06-13-18: Funnel tops missing from gages. One funnel top found near the street, the other top never recovered. Replaced batteries.

06-20-18: Removed secondary gage instrumentation and moved primary gage instruments to secondary base. Calibration checked.

07-23-18: Replaced battery. Site survey performed.

SITE 2: WINNETKA: WINNETKA PARK DISTRICT

09-10-97: Moved gage about 20 feet to the east of its previous location.

09-10-98: Replaced chart drive.

02-01-01: Replaced old gage with rebuilt gage with data logger.

08-10-01: Replaced chart drive.

06-06-02: Installed redesigned data logger.

08-01-02: Installed another redesigned data logger.

08-01-06: Replaced data logger.

01-02-07: Replaced vandalized gage.

07-02-07: Replaced data logger.

08-02-07: Replaced data logger that had a bad battery connection.

11-02-09: Replaced chart drive.

09-30-10: Replaced old gage with refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed. Waxed gage inlet and took pictures.

10-21-10: Installed external half wave dipole antenna.

10-29-10: Replaced data logger, battery, and malfunctioning modem.

11-9-10: Installed 10-watt rigid solar panel on south side of chain-link fence.

02-13-11: Snow from plow removed from around and over gage.

09-01-11: Grounded logger and modem to base of gage.

06-08-12: Moved gage 0.25 miles to the west.

07-08-12: Added ground rod, installed Wilson antenna with PolyPhaser surge protector.

08-25-13: Removed weeds in front of solar panel.

05-08-14: Moved gage about half-way (~30 feet) down the hill to alleviate wind loss issues.

01-21-15: Power cable to data logger from solar panel found chewed in half. Rewired cable.

04-29-15: Relevelled gage.

07-04-15: Placed ant traps in gage.

06-23-16: Battery, battery cable, modem power cable, RS232 cable, and solar power cable replaced. Calibration check was performed. Placed three ant traps in gage.

11-09-16: Relevelled gage.

12-06-16: Calibration checked.

04-03-17: Replaced battery.

06-21-17: Replaced battery. Rusty base plate replaced.

10-19-17: Replaced battery. Site survey performed.

05-03-18: Replaced battery.

06-25-18: Replaced battery. Calibration checked.

08-29-18: Replaced battery.

SITE 3: DES PLAINES: PRIVATE

09-10-98: Replaced chart drive.

11-12-98: Replaced chart drive.

02-01-01: Replaced old gage with rebuilt gage with data logger.

09-18-02: Installed redesigned data logger.

05-02-06: Replaced data logger.

05-02-07: Replaced data logger that had a bad battery connection.

12-02-08: Replaced chart drive.

01-01-10: Replaced data logger.

09-30-10: Replaced old gage with refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed. Waxed gage inlet and took pictures.

10-21-10: Installed Wilson antenna.

10-03-11: Grounded logger and modem to base of gage.

12-11-11: Rigid 10-watt solar panel installed.

07-08-12: Installed Wilson antenna with Polyphaser surge protector.

08-19-12: Added ground rod.

03-30-14: Recalibrated gage.

11-24-15: Replaced battery.

04-03-17: Replaced battery.

08-09-17: Checked calibration.

12-11-17: Replaced battery.

09-12-18: Checked calibration.

SITE 4: SKOKIE: PRIVATE / TALKING FARM

12-92: Moved gage 50 feet due east of the original location.

10-21-93: Replaced gage at same location after previous one accidentally destroyed by village personnel two weeks earlier.

02-15-94: Replaced gage again. Previous one vandalized.

04-20-94: Movement in 03-94 by village personnel necessitated a recalibration. Replaced chart drive and one support stake.

05-29-94: Replaced chart drive.

10-95: Replaced gage at same location.

09-10-98: Replaced chart drive.

02-01-01: Replaced old gage with rebuilt gage with data logger.

11-02-01: Removed trash from gage.

05-02-02: Removed trash from gage.

07-18-02: Installed redesigned data logger.

07-02-03: Replaced data logger.

06-06-05: Replaced data logger.

01-07-06: Replaced top cap.

09-06-06: Replaced chart drive. Removed trash from top cap.

11-01-06: Removed trash from gage.

12-02-06: Replaced bucket in gage.

01-01-07: Replaced data logger that had failed because of excessive corrosion, probably a result of the bucket leak.

02-01-07: Replaced data logger that had a bad battery connection.

06-01-07: Removed trash from gage funnel.

05-03-10: Dead robin found in gage and removed.

09-26-10: Replaced old gage with refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.

09-26-10: Took pictures and waxed gage inlet.

10-21-10: Installed Wilson antenna.

03-30-11: Bucket stolen.

04-06-11: Bucket replaced.

06-13-11: Moved gage about 300 feet to the northeast to the east side of the backyard of a private residence. A 6-foot wooden privacy fence is 3 feet to its east, a two-story house about 40 feet to its west, and a 50-foot tree is located about 50 feet to its south.

06-30-11: Installed 10-watt solar panel.

09-01-11: Grounded logger and modem to base of gage.

10-17-11: Solar panel relocated from the gage to a nearby fence.

07-08-12: Installed Wilson antenna with PolyPhaser surge protector.

08-19-12: Wilson antenna replaced with an omni antenna.

12-02-12: Moved site 500 feet to the Northeast to a neighboring backyard, 3 feet west of a 6-foot fence. Solar panel was placed on the fence.

01-04-14: Reconnected battery (disconnected 11-30-13).

11-24-15: Replaced battery.

08-25-16: Calibration performed.

07-19-17: Calibration performed.

07-30-18: Gage moved to new location: The Talking Farm at 3500 Howard St., Skokie. New site coordinates are 42.01793, -87.72150 with an elevation of 844 feet. Photos taken and site surveys performed at old and new sites. Gage calibrated.

SITE 5: FRANKLIN PARK: PRIVATE

10-21-93: Replaced bucket during a calibration visit.

11-12-98: Replaced chart drive.

02-01-01: Replaced old gage with rebuilt gage with data logger.

11-01-01: Replaced chart drive.

08-20-02: Installed redesigned data logger.

02-05-03: Replaced data logger.

08-19-04: Replaced gage and data logger.

11-04-04: Replaced chart drive.

07-07-05: Replaced data logger.

11-15-07: Replaced old gage with rebuilt gage.

11-02-09: Replaced chart drive.

09-30-10: Replaced old gage with refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed. Waxed gage inlet and took pictures.

10-21-10: Installed Wilson antenna.

10-03-11: Grounded logger and modem to base of gage.

07-08-12: Replaced Wilson antenna with Wilson antenna modified with a PolyPhaser surge protector.

08-19-12: Added ground rod, replaced modem.

11-17-16: Calibration checked.

08-09-17: Calibration checked.

04-19-18: Relevelled gage.

05-17-18: Replaced bucket, checked calibration, and performed site survey.

SITE 6: CHICAGO: PRECISION DIALOGUE DIRECT

07-12-93: Moved gage about 60 feet to the west-northwest to a backyard.

11-12-98: Replaced chart drive.

09-10-99: Replaced chart drive.

02-01-01: Replaced old gage with rebuilt gage with data logger.

08-01-02: Installed redesigned data logger.

04-01-04: Replaced data logger.

05-06-04: Replaced data logger.

02-02-05: Replaced data logger. When the replaced data logger was cleaned, an old spider web was found inside, causing intermittent noise problems.

09-26-10: Replaced old gage with refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed. Moved gage for better solar exposure.

09-26-10: Took pictures and waxed gage inlet.

10-21-10: Installed Wilson antenna.

06-13-11: Replaced T-base and replaced solar panel with 10-watt rigid panel.

07-11: Backyard tent installed covering gage.

10-03-11: Site moved about 2 miles northwest to the Chicago Paper and Tube Company. Grounded logger and modem to base of gage. Replaced data logger and changed antenna from Wilson to dipole.

- 08-12-12: Bucket removed from gage.
- 08-30-12: John Dudlak reinstalled bucket.
- 04-10-13: John Dudlak reinstalled bucket and cap.
- 08-15-13: Modem, data logger, and battery stolen.
- 09-25-13: Gage installed in small yard of Precision Dialogue Direct, 6 feet north of an east-west 6-foot fence and 10 feet south of a 35-foot building. The gage was grounded and calibrated.
- 12-09-15: Shell slightly dented.
- 09-13-16: Gage relocated about 0.5 miles at a heading of 252 degrees (west-southwest) from the previous location. Gage was leveled and calibrated.
- 11-17-16: Calibration checked.
- 09-13-17: Gage relocated about 0.48 miles at heading of 252 degrees (west-southwest) from the old location. Gage leveled and calibrated. New name for site is Chicago Laborers Training Facility. Site survey performed at old and new sites.
- 07-30-18: A decomposing bird was found in the collection bucket.
- 09-12-18: Calibration checked.

SITE 7: CHICAGO: BROADWAY UNITED METHODIST CHURCH / GRACELAND CEMETERY AND ARBORETUM

- 10-04-91: Moved to current location from Belmont Harbor boat landing (10-01-89 through 12-27-89); on the roof of the Lincoln Park Gun Club (12-27-89 through 06-28-91), and just north of Diversey Harbor in a playground (06-28-91 through 10-04-91).
- 04-20-94: Replaced chart drive.
- 5-17/19-96: Rotated gage base at the existing location to ensure a solid foundation.
- 11-12-98: Replaced chart drive.
- 02-01-01: Replaced old gage with rebuilt gage with data logger.
- 04-04-01: Removed considerable amount of gravel from the gage.
- 07-18-02: Installed redesigned data logger.

02-02-06: Replaced chart drive.

06-01-07: Removed debris (maple seeds, bird droppings) from gage funnel.

09-26-10: Replaced old gage with refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.

09-26-10: Took pictures and waxed gage inlet.

10-21-10: Installed Wilson antenna.

11-09-10: Moved gage 6 feet east to the east side of iron fence for better sun exposure.

06-30-11: Installed 10-watt solar panel.

10-17-11: Grounded logger and modem to base of gage.

07-08-12: Added ground rod, installed Wilson antenna with PolyPhaser surge protector.

09-23-12: Moved solar panel to the fence for better solar exposure.

07-2013: Battery replaced by resident.

08-25-13: Gage found with door open, solar panel disconnected, and modem wires connected to solar panel terminals. Wired properly, installed updated program into data logger with a command for the modem to turn on between 13:58 and 14:30 CST for maintenance purposes. Replaced data logger.

11-30-13: Replaced broken wire to solar panel and battery.

04-06-15: Bucket found to be off-center, touching inside of can. Relevelled T-base and replaced nuts and washers holding bucket in place.

09-25-15: Dead bird in collection bucket.

08-18-16: Dirt and debris were cleaned out from inside gage.

08-09-17: Checked calibration.

10-26-17: Photos taken.

11-29-17: Site survey performed.

06-20-18: Gage moved to new location: Graceland Cemetery near Clark and Irving Park Road. The new site latitude and longitude coordinates are 41.958972,

-87.657361 with an elevation of 616 feet. Photos taken and site surveys performed at new site. Battery replaced. Gage calibrated.

SITE 8: WESTCHESTER: FOREST PRESERVE

- 06-02-95: Replaced chart drive.
- 09-11-97: Replaced gage at same location due to vandalism damage.
- 10-30-97: Replaced gage at same location due to vandalism damage (sword passed through cylinder).
- 12-11-97: Moved gage to more secure location, about 300 feet west-northwest of its previous location. It is just south of the end point of the Forest Preserve entrance road on west side of the Forest Preserve property, with the garages of two private homes about 30 feet to the southeast and northeast.
- 11-12-98: Replaced chart drive.
- 02-01-01: Replaced old gage with rebuilt gage with data logger.
- 08-20-02: Installed redesigned data logger.
- 10-07-02: Because of vandalism, replaced and moved gage about 100 feet south-southwest of old location. New location is more open and more visible from nearby houses and further from Forest Preserve path.
- 11-21-02: Replaced data logger.
- 02-05-03: Replaced data logger.
- 03-04-04: Replaced data logger.
- 06-04-04: Removed ants from gage.
- 04-08-05: Used ant bait.
- 09-18-05: Replaced batteries in data logger.
- 03-03-07: Replaced ant traps.
- 04-17-08: Replaced old gage with rebuilt gage.
- 01-17-10: Installed co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel.
- 02-07-10: Installed omni antenna.

03-02-10: Installed Wilson antenna.

05-20-10: Installed different co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed. Moved gage and Wilson antenna 3 feet west to a sunnier location.

05-20-10: Took pictures.

07-11-10: Removed old gage. Took pictures.

09-30-10: Waxed gage inlet.

05-09-11: Replaced solar panel with 10-watt rigid panel.

10-02-11: Grounded logger and modem to base of gage.

03-19-12: Replaced refurbished gage.

07-02-12: Added ground rod, replaced modem, replaced the Wilson antenna with a dipole antenna.

07-15-12: Replaced dipole antenna with Wilson antenna modified with a PolyPhaser surge protector.

07-27-16: Placed ant trap in gage.

12-06-16: Calibration checked.

05-18-17: Calibration checked.

10-19-17: Site survey performed.

06-25-18: Calibration checked.

SITE 9: CICERO: WATER STATION

10-28-93: Replaced chart drive during a calibration visit.

04-20-94: Replaced chart drive, repaired outer case.

06-24-94: Replaced outer case.

09-11-97: Replaced gage at same location.

04-09-98: After three instances of vandalism, replaced and relocated gage to the Cicero Water Station about 1.3 miles north of the old location. The gage is in the center of a 1-acre field, with a 150-foot tower 150 feet to the south, a

75-foot tree 100 feet to the north, a 20-foot building 100 feet to the east, and a 20-foot building 200 feet to the west.

- 04-30-98: Replaced chart drive.
- 02-01-01: Replaced old gage with rebuilt gage with data logger.
- 07-01-01: Moved gage to a protected area east of the service area, about 5 feet from a building, because of the construction of a new water tower.
- 06-07-02: Moved gage about 0.5 miles to Cicero Water Station on Roosevelt Drive. It is in a more open area, in the center of a 50- by 100-foot grassy lot, 50 feet west of a 20-foot water tank.
- 07-01-02: Installed redesigned data logger.
- 09-05: Gage, data logger, and T-base stolen.
- 09-18-05: Installed gage at new site in Berwyn about 2 miles west of old location. Gage is in backyard of a residence, approximately 10 feet east of a 1.5-story house, and about 30 feet west of a one-story garage.
- 01-07-06: Replaced chart drive.
- 04-06-06: Replaced linear potentiometer.
- 04-02-08: Replaced data logger.
- 08-11-08: Gage moved to a new site at the Columbus Park Golf Course in Oak Park. Gage is about 1.5 miles northeast of previous location, and about 2 miles north of its long-time location in Cicero. It is about 10 feet south of the course one-story utility shed on the east border of the driving range.
- 04-04-09: Replaced chart drive.
- 08-08-10: Installed co-located refurbished gage with Campbell data logger, modem, antenna, 9-volt battery, and wrap-around solar panel. New welded T-base installed.
- 08-08-10: Took pictures.
- 09-30-10: Waxed gage inlet.
- 10-21-10: Soldered potentiometer connections.
- 11-10: Older co-located gage stolen. Top cap of new gage stolen.
- 03-14-11: Replaced stolen refurbished gage. Moved gage 1 mile southeast to a previous location at Cicero Water Station on south Laramie. It is located 10

feet west of a 6-foot chain-link fence, 20 feet south of a single-story building, and 130 feet southeast of a 100-foot tall water tower.

- 06-30-11: Replaced gage.
- 10-17-11: Grounded logger and modem to base of gage.
- 03-30-14: Recalibrated gage.
- 04-29-15: Omni antenna installed.
- 12-09-15: Replaced battery.
- 11-17-16: Calibration checked.
- 10-12-17: Calibration checked, battery replaced, site survey performed, and pictures taken.

SITE 10: CHICAGO: CHICAGO SCENIC STUDIOS

- 02-05-99: Replaced chart drive.
- 02-01-01: Replaced old gage with rebuilt gage with data logger.
- 06-06-02: Replaced chart drive.
- 07-18-02: Installed redesigned data logger.
- 04-02-03: Moved gage away from encroaching spruce tree, positioned about 5 feet east of 40-foot spruce, 5 feet north of one-story garage, and 15 feet west of two-story building.
- 03-02-07: Installed ant trap.
- 03-04-07: Replaced data logger that had a bad battery connection.
- 04-17-08: Replaced gage with rebuilt gage.
- 05-03-10: Found gage had been tampered with mid-April. Moved gage 3 feet to the west.
- 08-08-10: Replaced old gage with refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel.
- 08-08-10: Took pictures.
- 09-01-10: Replaced battery with a recharged 12-volt battery.

09-30-10: Waxed gage inlet.

10-21-10: Installed Wilson antenna.

10-29-10: Installed a 15-watt rigid solar panel.

11-09-10: Replaced solar panel with a rigid 10-watt panel.

05-09-11: Replaced entire gage, data logger, and malfunctioning modem.

10-17-11: Grounded logger and modem to base of gage.

07-08-12: Installed Wilson antenna with PolyPhaser surge protector.

11-30-13: Bucket emptied as it reached its limit on November 11.

03-30-14: Recalibrated gage.

11-24-15: Replaced battery.

12-06-16: Calibration checked.

03-16-17: Gage releveled and battery replaced.

10-19-17: Removed a metal drying rack that was on top of gage.

10-30-17: Gage moved to new location: Chicago Scenic Studios near S. Halsted St. and W. Cermak Rd. New latitude and longitude coordinates are 41.850778, -87.6485. Photos taken and site surveys performed at old and new sites. Battery replaced. Gage calibrated.

SITE 11: LA GRANGE: EDGEWOOD VALLEY COUNTRY CLUB

02-05-99: Replaced chart drive.

02-01-01: Installed rebuilt gage with data logger, while keeping the old gage for comparison purposes.

04-18-01: Moved both gages to new location along north edge of Edgewood Valley Country Club. Gages at highest point of golf course, about 60 feet from fence line separating the club from the 294 Tollway.

05-23-02: Installed redesigned data logger.

06-06-02: Tightened terminal strip pigtail connectors joining the potentiometer and data logger.

06-04-03: Removed ants and ant nest from gage.

04-02-04: Moved gage 10 feet to the east to a grassier area. Removed ants from gage.

06-04-04: Removed ants from gage.

04-08-05: Used ant bait.

03-03-07: Replaced ant traps.

06-01-07: Replaced ant traps. Removed debris (maple seeds, bird droppings) from gage funnel.

05-01-08: Replaced data logger.

02-01-10: Replaced chart drive.

05-03-10: Dead robin found in gage and removed.

05-20-10: Installed co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.

05-20-10: Took pictures.

07-11-10: Removed old gage. Took pictures.

09-30-10: Waxed gage inlet.

06-13-11: Replaced malfunctioning modem.

09-01-11: Grounded logger and modem to base of gage.

04-29-12: Replaced refurbished gage.

07-15-12: Added ground rod.

04-29-15: Relevelled gage.

09-25-15: Tightened base plate.

12-10-15: Replaced battery.

03-22-16: Placed ant traps in gage.

07-26-16: Replaced battery and placed ant trap inside gage.

03-16-17: Gage relevelled and battery replaced.

06-28-17: Replaced battery and calibrated gage.

12-06-17: Replaced battery.

07-09-18: Replaced battery.

SITE 12: BEDFORD PARK: HALLSTAR

11-24-92: Moved gage west 0.9 miles, north of an office building.

05-17-93: Moved gage about 400–500 feet to the southwest along a service drive in a mowed grassy area.

09-11-97: Replaced gage after damaged by a truck. Its new location is about 10 feet to the southwest of its previous location, up a small incline and closer to a 6-foot chain-link fence. It is approximately 35 feet east of a two-story building.

02-05-99: Replaced chart drive.

09-10-99: Replaced drum cylinder.

02-01-01: Replaced old gage with rebuilt gage with data logger.

07-01-02: Installed redesigned data logger.

02-05-03: Replaced data logger.

07-02-03: Replaced data logger.

03-01-06: Replaced data logger.

04-04-09: Replaced old gage with rebuilt gage with data logger.

08-08-10: Replaced old gage with refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.

08-08-10: Took pictures.

09-30-10: Waxed gage inlet.

10-29/30-10: Installed Wilson antenna.

10-17-11: Grounded logger and modem to base of gage.

07-08-12: Added ground rod.

- 12-02-12: Replaced the flex solar panel with a rigid panel.
- 05-05-13: Replaced the gage, modem, data logger, and battery.
- 03-28-17: Gage releveled.
- 06-14-17: Moved about 300 feet at heading of 168 degrees to grass area between concrete pad and storm retention basin. Gage was leveled and calibrated. Site survey performed.

**SITE 13: CHICAGO: GREUNE COAL COMPANY /
CHICAGO POLICE DEPARTMENT**

- 03-15-95: Moved gage from Eggleston Street to a sheltered coal yard of the Greune Coal Company on Onion Street, about four blocks due west of the old position, and replaced the chart drive.
- 12-06-95: Replaced T-base.
- 5-17/19-96: Replaced T-base.
- 02-22-99: Replaced chart drive.
- 05-03-99: Found gage moved about 10 feet to the southwest, to a “well-protected” position, about 7 feet from a 10-foot wall and 30 feet from a 25-foot tall elevated-train retaining wall.
- 02-01-01: Replaced old gage with rebuilt gage with data logger.
- 07-01-02: Installed redesigned data logger.
- 11-04-03: Replaced chart drive.
- 06-04-04: Replaced data logger.
- 09-15-10: Replaced old gage with refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel.
- 09-30-10: Waxed gage inlet.
- 10-21-10: Installed external half wave dipole antenna.
- 03-02-11: Replaced gage. Found gage had been moved within site and bucket moved off center.
- 09-01-11: Grounded logger and modem to base of gage.

- 09-19-11: Moved gage 50 feet east, from ground and wooden base to 6-foot wall with a saddle base.
- 07-02-12: Replaced Wilson antenna with a dipole antenna.
- 12-10-15: Replaced battery. Bagel in collection bucket.
- 03-29-16: Replaced battery. Gage had been moved about 65 feet to the northeast. No damage observed to the bucket, gage, or instrumentation. Bucket was slightly off center on the base plate. Re-centered bucket.
- 09-20-16: Calibration performed and battery replaced.
- 11-30-16: Gage moved to south side of a pillar for better sun exposure. Calibration performed. Replaced battery.
- 06-14-17: Replaced battery.
- 11-29-17: Gage moved to new location: Chicago Police Department District 6, 7808 S. Halsted St. New latitude and longitude coordinates are 41.75153, -87.64439. Elevation of 613 feet. Photos taken and site surveys performed at old and new sites. Battery replaced. Gage calibrated.
- 12-06-17: New dipole antenna installed.
- 04-19-18: Replaced battery.
- 06-13-18: Replaced battery. Calibrated checked. Replaced dipole antenna with omni antenna.

SITE 14: CHICAGO: SOUTH WATER PURIFICATION PLANT

- 03-19-95: Replaced chart drive.
- 12-06-95: Replaced T-base.
- 06-13-96: Replaced gage at same location after being hit by a riding lawn mower on June 10.
- 10-09-96: Installed snow shield.
- 04-30-98: Replaced chart drive.
- 02-15-01: Installed rebuilt gage with data logger, while keeping the old gage for comparison purposes.
- 10-03-01: Replaced chart drive. Installed Alter shield on rebuilt gage after removing old gage.

06-06-02: Installed redesigned data logger.

09-15-10: Replaced old gage with refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.

09-30-10: Waxed gage inlet.

10-29/30-10: Installed Wilson antenna.

09-01-11: Grounded logger and modem to base of gage.

09-19-11: Replaced refurbished gage.

07-02-12: Added ground rod, replaced modem, replaced the Wilson antenna with a Wilson antenna modified with a PolyPhaser surge protector.

04-29-15: Releveled gage.

12-10-15: Replaced battery.

11-30-16: Calibration performed and battery replaced.

03-16-17: Gage releveled and battery replaced.

10-12-17: Gage releveled, battery replaced, calibration checked, site survey performed, and pictures taken.

SITE 15: LEMONT: SAINT MARY'S SEMINARY

11-22-94: Moved gage about 1.5 miles east from MWRDGC complex in Lemont to the grounds of the Franciscan Fathers on Main Street in Lemont.

02-05-99: Replaced chart drive.

01-13-01: Installed rebuilt gage with data logger, while keeping the old gage for comparison purposes.

11-15-01: Replaced chart drive.

06-06-02: Tightened terminal strip connectors.

06-24-02: Installed redesigned data logger.

08-01-03: Replaced data logger.

09-03-03: Replaced data logger.

12-15-03: Tightened terminal strip connectors.

04-08-05: Used ant bait.

11-02-07: Remounted gage after being hit by mower on October 26.

01-01-10: Replaced chart drive.

01-17-10: Installed co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.

07-11-10: Took pictures.

09-30-10: Waxed gage inlet.

09-01-11: Grounded logger and modem to base of gage.

09-19-11: Replaced refurbished gage.

12-11-11: Rigid 10-watt solar panel installed.

12-18-11: Removed co-located gage.

07-15-12: Added ground rod, installed Wilson antenna with PolyPhaser surge protector.

11-24-15: Replaced battery.

08-18-16: Weeds and tall grass were removed from in front of solar panel.

11-30-16: Replaced battery.

03-28-17: Gage releveled.

06-28-17: Replaced battery and calibrated gage.

03-22-18: Site survey performed, photos taken.

SITE 16: PALOS PARK: PRIVATE / SWALLOW CLIFF STAIRS FOREST PRESERVE

02-05-99: Replaced chart drive.

02-01-01: Replaced old gage with rebuilt gage with data logger.

11-01-01: Replaced terminal strip connectors.

06-24-02: Installed redesigned data logger.

06-17-03: Replaced data logger.

08-01-03: Replaced data logger.

06-17-04: Replaced data logger.

09-06-06: Replaced chart drive.

11-15-07: Replaced data logger.

08-08-10: Replaced old gage with refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel.

08-08-10: Took pictures.

09-30-10: Waxed gage inlet.

09-01-11: Grounded logger and modem to base of gage.

03-30-14: Leveled gage.

12-02-14: Readjusted out of alignment plate on tower. Recalibrated gage.

04-29-15: Releveled gage. Tightened arm holding potentiometer.

06-05-15: Replaced modem found to be infested with ants and ant eggs.

07-05-15: Replaced battery. Placed ant traps in gage.

08-28-15: Replaced modem and null cable. Reoriented antenna.

12-04-15: Replaced battery.

03-22-16: Replaced ant traps.

05-26-16: Replaced gage housing with new housing containing a 7W solar panel and omni directional antenna. Gage leveled and calibration checked. Extra ant traps installed.

10-25-16: Gage leveled and calibration was checked.

12-06-16: Calibration checked.

01-24-17: Replaced battery.

10-19-17: Releveled gage, replaced battery, photos taken, and site survey performed.

- 10-30-17: Gage moved to new location: Swallow Cliff Woods North of the Cook County Forest Preserve located near LaGrange Rd. S. and Route 83. New latitude and longitude coordinates are 41.680194, -87.861722. Photos taken and site surveys performed at new site. Battery replaced. Gage calibrated.
- 12-06-17: Replaced battery.
- 07-09-18: Omni antenna mount broken, dipole antenna installed.
- 07-25-18: Replaced antenna cable. Calibration checked.
- 07-30-18: Removed dipole antenna, installed omni antenna.

SITE 17: ALSIP: FIRE DEPARTMENT STATION #2

- 11-04-93: Replaced chart drive during a calibration visit.
- 06-24-94: Replaced chart drive.
- 08-09-94: Moved gage about 150 yards south-southeast from Sardee Industries to Alsip Fire Department Station #2.
- 11-21-96: Replaced gage at same location.
- 02-05-99: Replaced chart drive.
- 07-21-00: Replaced chart drive.
- 01-24-01: Installed rebuilt gage with data logger, while keeping the old gage for comparison purposes.
- 11-01-01: Replaced terminal strip connectors.
- 06-06-02: Installed redesigned data logger.
- 05-26-04: Replaced gage.
- 06-16-06: Replaced gage and linear potentiometer.
- 07-11-10: Installed co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.
- 08-08-10: Installed omni antenna.
- 09-30-10: Waxed gage inlet.

10-21-10: Soldered potentiometer connections.

01-03-11: Replaced top cap on original gage.

09-01-11: Grounded logger and modem to base of gage.

12-18-11: Removed co-located gage.

07-08-12: Added ground rod.

01-21-15: Replaced power cable from modem to data logger.

02-23-15: Replaced modem.

04-29-15: Relevelled gage.

09-20-16: Calibration checked.

09-20-17: Performed site survey, took pictures, and checked calibration.

09-27-18: Calibration checked.

SITE 18: CHICAGO: AXLE TECH INTERNATIONAL

11-04-93: Replaced chart drive during a calibration visit.

08-09-94: Moved gage about 150 feet north of previous location in work yard.

02-22-99: Replaced chart drive.

02-01-01: Replaced old gage with rebuilt gage with data logger.

11-15-01: Replaced chart drive.

05-23-02: Installed redesigned data logger.

06-06-02: Tightened terminal strip connectors.

03-05-03: Moved site from Ingersol to Heat Treat.

04-02-03: Moved gage to more secure position on same property after vandalism. Gage is positioned about 600 feet north-northeast of location at Ingersol in center of a fenced area, south of employee parking. Replaced chart drive and data logger.

05-01-03: Removed wasp nest from gage.

09-03-03: Replaced data logger.

06-04-04: Replaced data logger.

06-04-04: Removed ants from gage.

03-03-07: Replaced ant traps.

09-15-10: Installed co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.

09-26-10: Took pictures.

09-30-10: Waxed gage inlet.

10-21-10: Installed Wilson antenna.

09-01-11: Removed co-located gage.

09-01-11: Grounded logger and modem to base of gage.

07-02-12: Added ground rod and replaced Wilson antenna with an omni antenna.

03-30-14: Recalibrated gage.

04-29-15: Releveled gage.

12-10-15: Replaced battery.

05-26-16: Removed ants from gage. Replaced modem RS232 cable, modem power cable, and data logger. New program sent to logger (5 sec.). Releveled gage. Calibration check performed for a new multiplier and offset for the program.

12-06-16: Replaced battery.

09-20-17: Calibration performed. Decomposing bird found in the collection bucket.

11-22-17: Replaced battery.

07-09-18: Replaced battery. Calibration checked.

09-05-18: Upon arrival, solar panel and battery were found to be unplugged. Modem, modem power cable, and serial cable replaced.

SITE 19: CHICAGO: GALLO EQUIPMENT

11-24-92: Moved gage 50 feet west to grassy area just north of a shop building and just south of an entrance drive.

5-17/19-96: Rotated gage base at the existing location to ensure a solid foundation.

02-22-99: Replaced chart drive.

01-13-01: Installed rebuilt gage with data logger, while keeping the old gage for comparison purposes.

10-03-01: Replaced chart drive.

06-24-02: Installed redesigned data logger. Tightened terminal strip connectors.

02-14-08: Replaced data logger.

04-17-08: Replaced old gage with rebuilt gage, and replaced data logger.

09-15-10: Installed co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed. Co-located gage site is 36 feet to the north of old location.

09-30-10: Waxed gage inlet.

10-21-10: Installed Wilson antenna.

07-14-11: Moved gages 0.45 miles north to the parking lot of Gallo's Equipment. A 6-foot tall chain-link fence is 3 feet to its south, a 30-foot tall commercial building 45 feet to its southeast.

09-01-11: Grounded logger and modem to base of gage.

09-19-11: Removed co-located gage.

07-02-12: Added ground rod and replaced Wilson antenna with a dipole antenna.

10-31-12: Replaced modem.

12-02-12: Replaced the flex solar panel with a rigid panel.

03-30-14: Recalibrated gage.

04-29-15: Installed omni antenna.

09-25-15: Replaced modem power cable as very dirty. Cleaned modem as found filled with debris and dirt.

03-22-16: Placed ant traps in gage.

11-30-16: Calibration checked.

09-28-17: Calibration checked. Site survey performed and pictures taken.

09-27-18: Calibration checked. Replaced battery.

SITE 20: ORLAND PARK: PANDUIT CORPORATION

03-16-90: Moved gage about 0.25 miles to the northwest to rural property about 30 feet east of a welding shop.

5-17/19-96: Rotated gage base at the existing location to ensure a solid foundation.

04-30-98: Replaced chart drive.

02-15-01: Installed rebuilt gage with data logger, while keeping the old gage for comparison purposes.

03-06-02: Installed redesigned data logger.

07-02-03: Moved gage about 30 feet to south of previous location; it is located about 30 feet east of a welding shop, 60 feet east-southeast of a 30-foot pine, and 50 feet west of a 40-foot tree line.

05-26-04: Replaced gage.

09-06-06: Restored top cap to proper position after being vandalized.

01-02-07: Replaced data logger that had a bad battery connection.

02-02-07: Replaced data logger that had a bad battery connection.

03-03-07: Replaced ant traps.

06-01-07: Removed debris (maple seeds, bird droppings) from gage funnel.

11-02-07: Remounted gage after being hit by mower on July 10.

04-03-08: Leveled the gage after it had been vandalized on March 29.

05-01-08: Moved gage to new location at Panduit Corporation, about 600 feet to the NNW of the old location. Site is along the fence line of the western border of the property.

12-02-08: Replaced chart drive.

05-20-10: Installed co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel.

07-11-10: Removed old gage.

09-30-10: Waxed gage inlet.
10-21-10: Soldered potentiometer connections.
09-19-11: Grounded logger and modem to base of gage.
07-08-12: Added ground rod.
05-05-13: Replaced modem.
12-06-16: Calibration checked.
02-01-17: Replaced battery.
09-28-17: A decomposing bird was found in the collection bucket. Calibration checked, site survey performed, and pictures taken.
11-22-17: Replaced battery.
07-23-18: Replaced battery.
09-27-18: Calibration checked.

SITE 21: TINLEY PARK: PRIVATE

02-16-95: Replaced chart drive.
05-22-95: Replaced chart drive again.
02-01-01: Replaced old gage with rebuilt gage with data logger.
08-10-01: Replaced chart drive.
05-02-02: Installed redesigned data logger.
11-04-03: Replaced chart drive.
05-07-04: Replaced data logger.
06-04-04: Removed ants from gage.
12-02-08: Replaced chart drive.
01-01-10: Replaced data logger.
03-03-10: Replaced data logger.

07-11-10: Installed refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.

07-11-10: Took pictures.

08-08-10: Installed omni antenna.

09-30-10: Waxed gage inlet.

10-21-10: Installed Wilson antenna.

06-13-11: Replaced T-base and replaced solar panel with 10-watt rigid panel. Moved gage 4 feet to the north for better solar exposure.

09-19-11: Grounded logger and modem to base of gage. Cleared weeds obstructing solar panel.

04-29-12: Replaced modem.

07-02-12: Added ground rod and replaced Wilson antenna with a dipole antenna.

07-15-12: Replaced dipole antenna with Wilson antenna modified with a PolyPhaser surge protector.

08-19-12: Patio blocks were laid around gage to keep weed growth away from solar panel.

05-15-13: Reinstalled modem repaired at ISWS.

12-02-14: Replaced gage and data logger.

09-20-16: Calibration performed and battery replaced.

09-06-17: Calibration performed, site survey performed, and battery replaced.

09-27-18: Calibration performed and battery replaced.

SITE 22: HARVEY: ARMY RESERVE BUILDING / WHIMSY INTERMODAL (same location, new owner)

11-02-90: Moved gage about 100 feet to the southeast, between a parking lot and an Army Reserve building, just north of a reserve storage area.

02-22-99: Replaced chart drive.

01-13-01: Installed rebuilt gage with data logger, while keeping the old gage for comparison purposes.

04-18-02: Installed redesigned data logger.

06-06-02: Tightened terminal strip connectors.

06-18-02: Replaced data logger.

08-06-03: Tightened terminal strip connectors and replaced data logger.

04-02-04: Replaced data logger.

05-05-05: Replaced data logger.

09-03-08: Replaced the evaporation shield (top cap), which had been stolen.

05-03-10: Repositioned gage as it was found tilted at 60° angle and amounts low for last week of month.

07-11-10: Installed refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.

07-11-10: Took pictures.

09-15-10: Installed omni antenna.

09-30-10: Waxed gage inlet.

09-01-11: Grounded logger and modem to base of gage.

03-30-14: Recalibrated and leveled gage.

05-08-15: Replaced gage and data logger.

10-29-15: Repositioned bucket to keep edges as far from the inside shell as possible.

04-14-16: Extra nut was added to hold potentiometer to arm more firmly. Calibrated gage.

06-09-16: Replaced gage, logger, can, funnel, bucket, solar power cable, and modem power cable. Gage was leveled and re-calibrated.

11-09-16: Releveled gage.

12-06-16: Calibration checked.

02-01-17: Replaced battery.

09-06-17: Calibration checked.

07-25-18: Calibration checked.

09-20-18: Moved gage to a temporary location 206 feet NE of old location. Calibration checked. Pictures taken. New temporary site coordinates are N 41°35'09.72", W 87°37'58.73" at an elevation of 632 feet. Site survey performed.

SITE 23: LANSING: POLICE DEPARTMENT

04-24-96: Moved gage 150 feet south of the previous location at the request of the property manager.

5-15/17-96: Moved site slightly, so it is evenly spaced between two trees (one about 15 feet to the south and one about 15 feet to the north). It is close to the site where it was moved on 04-24-96, still about 150 feet south of the previous long-standing location.

04-30-98: Replaced and relocated the gage approximately 0.5 miles to the west, to a well-exposed location on the property of the Lansing Police Department. A one-story building is 100 feet to the east, and 170th St. is about 1000 feet to the south.

01-24-01: Installed rebuilt gage with data logger, while keeping the old gage for comparison purposes.

04-18-02: Installed redesigned data logger.

08-01-03: Removed ant nest from gage.

09-06-06: Replaced ant traps. Unclogged top cap.

03-03-07: Replaced ant traps.

02-02-09: Replaced chart drive.

04-04-09: Replaced chart drive.

01-17-10: Installed co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel.

08-08-10: Took pictures.

09-30-10: Waxed gage inlet.

09-01-11: Grounded logger and modem to base of gage.

09-19-11: Replaced refurbished gage.

01-27-12: Replaced refurbished gage.

07-02-12: Added ground rod.

12-03-15: Replaced battery.

03-22-16: Replaced ant traps.

11-30-16: Calibration checked.

09-06-17: Performed site survey, took pictures, and checked calibration.

09-20-17: After large false positive precipitation noticed, visited gage and found light yellow liquid in bucket.

07-25-18: Calibration checked.

12-05-18: Replaced battery.

SITE 24: MATTESON: POLICE DEPARTMENT

06-11-98: Drum cylinder discovered stolen and subsequently replaced.

05-07-99: Moved site about 30 feet to the west, about 50 feet away from two 20-foot trees, one to the southwest and one to the southeast, about 30 feet away from a newly dug trench and building site.

01-13-01: Installed rebuilt gage with data logger, while keeping the old gage for comparison purposes.

11-01-01: Replaced terminal strip connectors.

04-04-02: Installed redesigned data logger.

05-02-02: Removed ants from gage.

07-02-03: Removed ants from gage.

06-04-04: Removed ants from gage.

09-01-05: Replaced data logger.

01-02-07: Replaced pigtail connector in potentiometer.

05-04-07: Replaced data logger which had bad battery connection.

01-17-10: Installed co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel.

05-20-10: Took pictures.

07-11-10: Replaced co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.

07-11-10: Took pictures.

09-30-10: Waxed gage inlet.

09-01-11: Grounded logger and modem to base of gage.

12-18-11: Removed co-located gage.

07-02-12: Added ground rod.

06-03-13: Removed bird from gage.

02-27-14: Retrieved gage from network as it had been buried by a snow plow (and damaged) on about 02-17-14.

03-21-14: Replaced gage in network.

05-08-14: Gage had been used as a drug receptacle and was emptied. No obvious loss of precipitation.

12-02-14: Repositioned solar panel to face more towards the south.

12-03-15: Replaced battery and calibrated gage.

03-11-15: A large amount of pills, dissolved pills, and pill bottle desiccant packs found in bucket.

04-14-15: Leveled gage. Gage would not easily calibrate. Replaced gage, battery, and logger. Loaded 5-second program onto logger. Calibrated gage for new multiplier and offset.

06-23-16: Replaced battery and battery power cable.

09-20-16: Replaced battery, solar panel, and gage shell.

12-13-16: Replaced battery.

01-24-17: Replaced battery.

04-27-17: Removed a large, dead bird from bucket. Ants had built a nest inside the modem. Replaced battery, modem, antenna, and cables.

09-20-17: Noticed a small tree to the southeast of the gage had been cut down recently. Calibration and site survey performed and battery, gage shell, and solar panel were replaced.

07-25-18: Calibration checked.

SITE 25: CHICAGO HEIGHTS: BIG JOHN'S FARM STAND

11-04-93: Replaced chart drive during a calibration visit.

02-15-94: Replaced chart drive.

01-13-01: Installed rebuilt gage with data logger, while keeping the old gage for comparison purposes.

03-06-02: Installed redesigned data logger.

06-17-04: Replaced data logger.

08-04-05: Installed co-located gage and data logger.

07-19-07: Removed two co-located gages and replaced with a single refurbished gage. The two gages were installed in backyard of the ISWS for further monitoring.

05-03-10: Gage found moved several feet from its previous location.

05-20-10: Moved gage west 330 feet to more open, less trafficked area. Installed co-located refurbished gage with Campbell data logger, modem, antenna, 12-volt battery, and wrap-around solar panel. New welded T-base installed.

08-08-10: Took pictures.

09-30-10: Waxed gage inlet.

07-14-11: Replaced gage and data logger.

09-01-11: Removed co-located gage.

09-01-11: Grounded logger and modem to base of gage.

04-29-12: Leveled T-base.

07-02-12: Added ground rod and replaced Wilson antenna with a dipole antenna.

05-05-13: Site had flooded, with evidence of 4 inches of water inside the case. Water had completely covered the modem and battery, and partially covered the data logger.

05-15-13: Reinstalled, cleaned, and calibrated gage with new modem. T-base replaced with one 10 inches taller.

07-30-15: Apparently hit by something. Gage found dented, causing bucket to rub against inside of can. Dent pounded out and gage releveled.

12-3-15: Replaced battery.

10-19-16: Latitude, longitude, and elevation were recorded.

11-30-16: Calibration checked.

01-24-17: Replaced battery.

04-27-17: Replaced battery.

06-28-17: Gage shell and solar panel replaced. Gage was leveled. Calibration could not be performed due to high wind conditions.

09-06-17: Calibration checked, site survey performed, and pictures taken.

07-25-18: Calibration checked.

12-05-18: Replaced battery.

APPENDIX VII: ISOHYETAL MAPS OF ANNUAL PRECIPITATION FOR WYS 1990–2017⁴

Annual water year precipitation maps are presented four to a page. Table VII-1 lists the water year and page number for convenience.

Table VII-1. Water Year of Annual Isohytel Maps with Page Number

<i>Water Year</i>	<i>Page</i>
1990–1993	87
1994–1997	88
1998–2001	89
2002–2005	90
2006–2009	91
2010–2013	92
2014–2017	93

4: Historical information has been included in this report as required by the sponsor. Appendix IV content was reproduced from Bauer, 2018 and updated for WY2018.

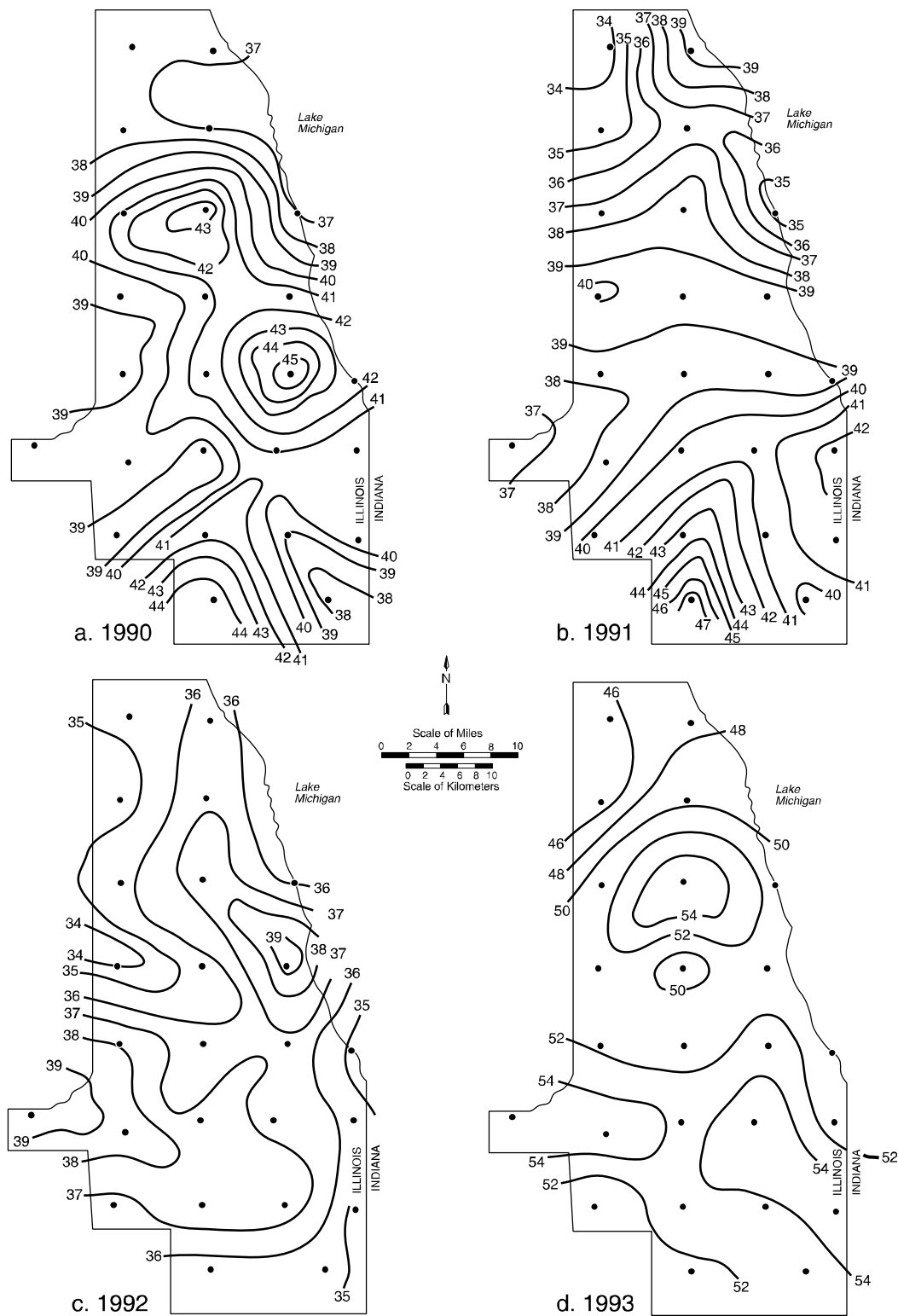


Figure AVII-1(a-d). Precipitation isohyets (inches) for WYs 1990–2017

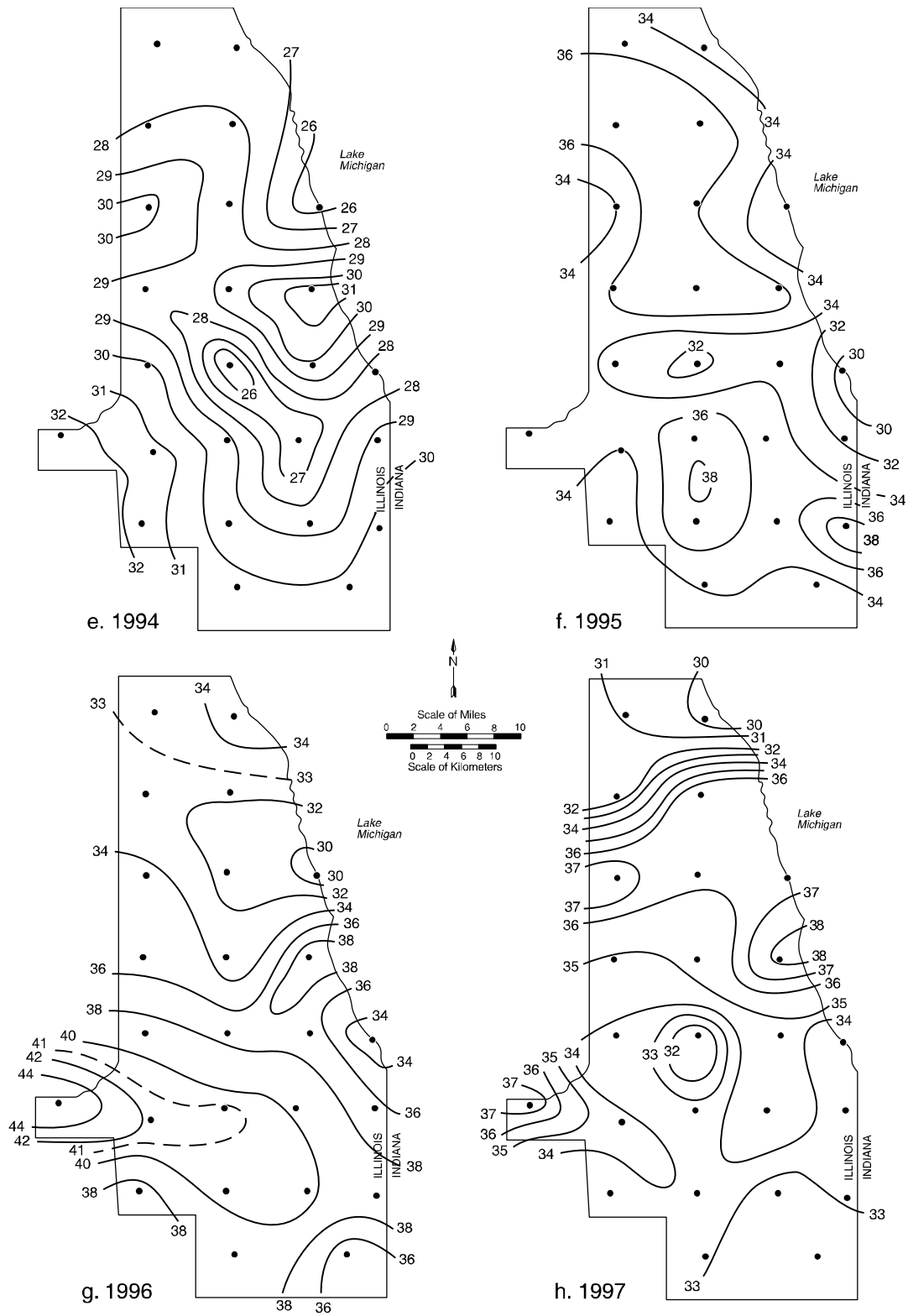


Figure AVII-1(e-h). Continued

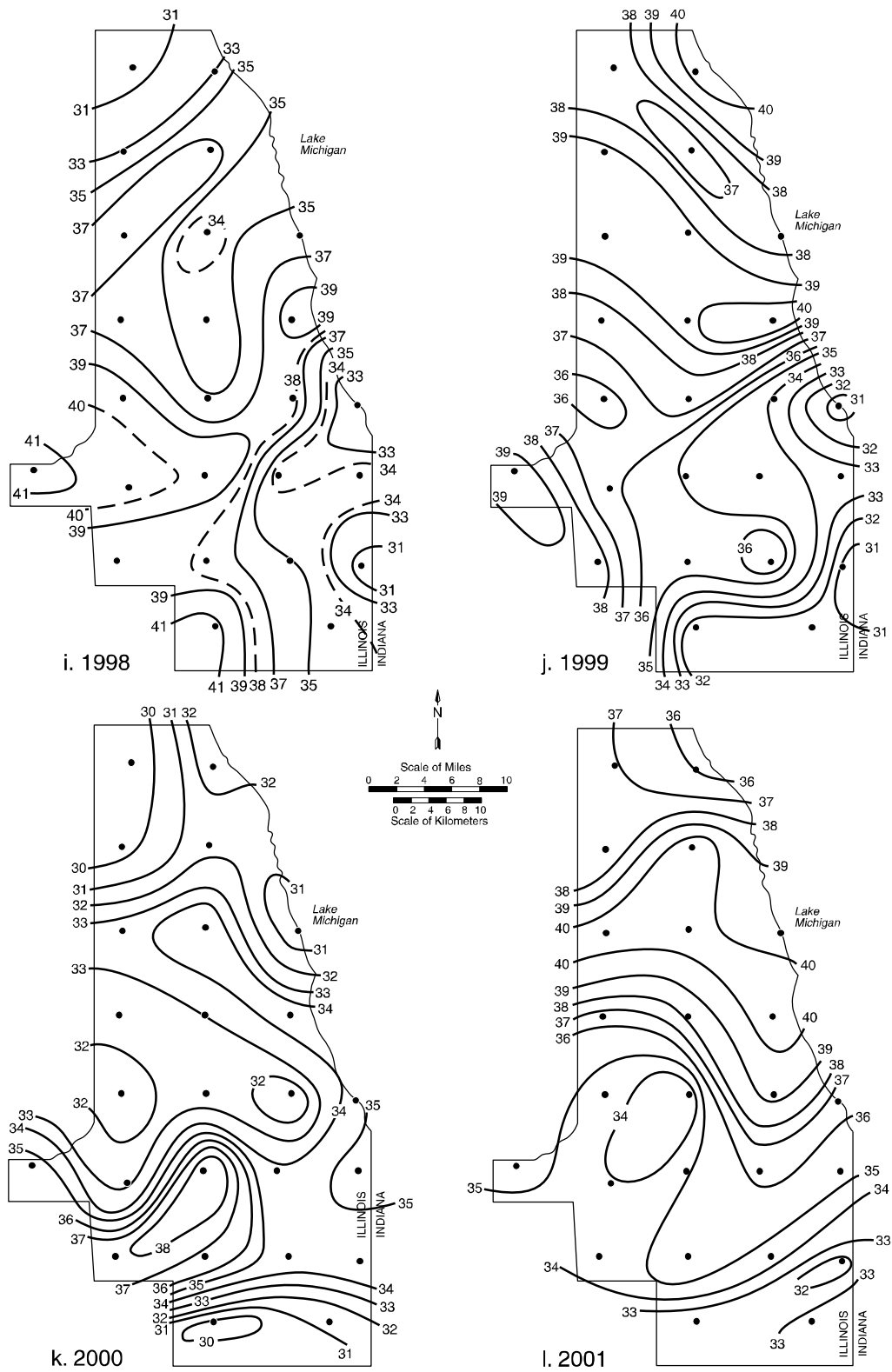


Figure AVII-1(i-I). Continued

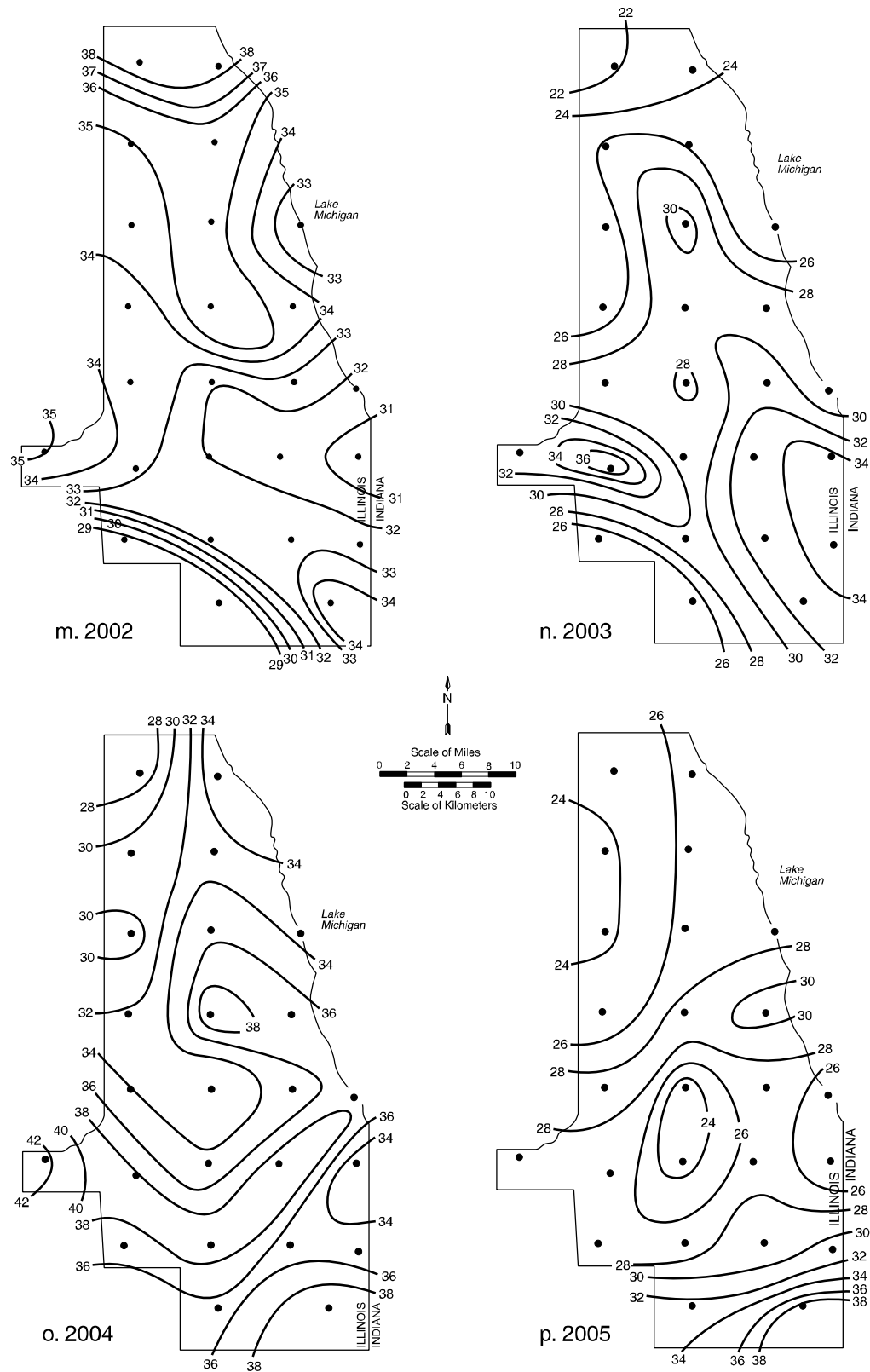


Figure AVII-1(m-p). Continued

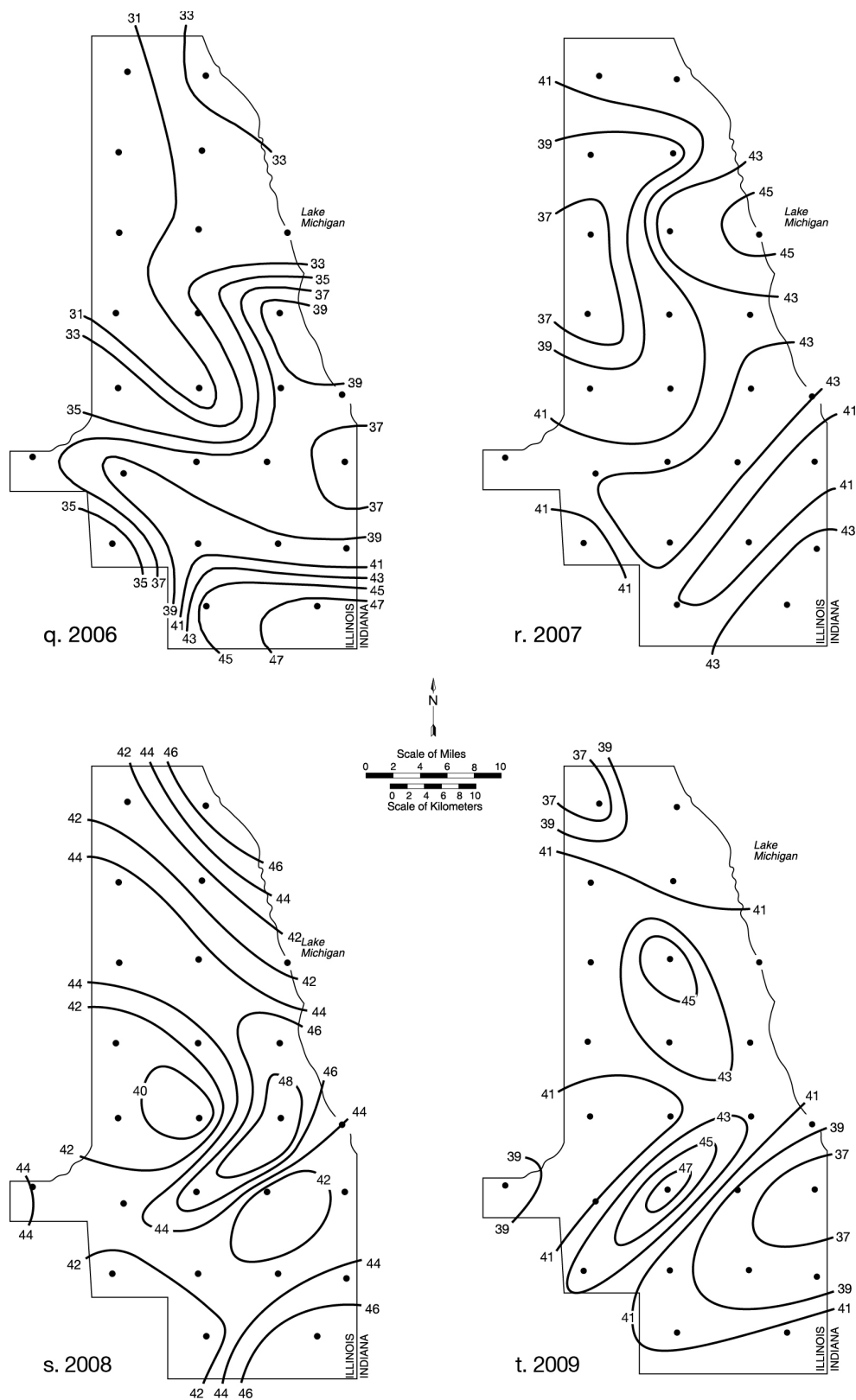


Figure AVII-1(q-t). Continued

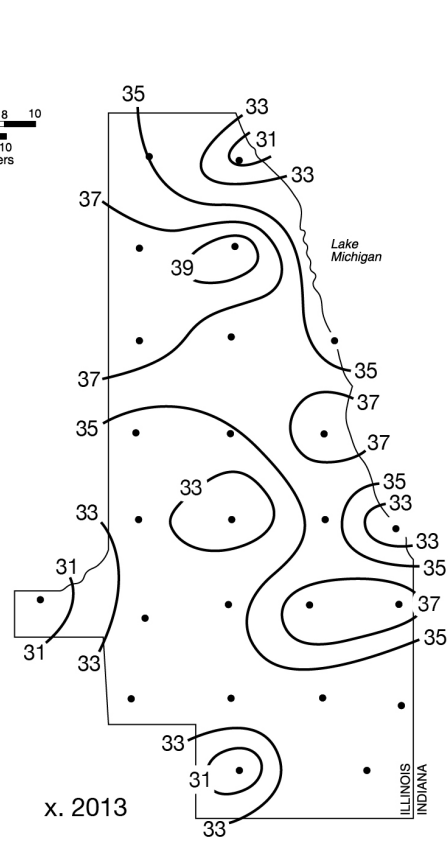
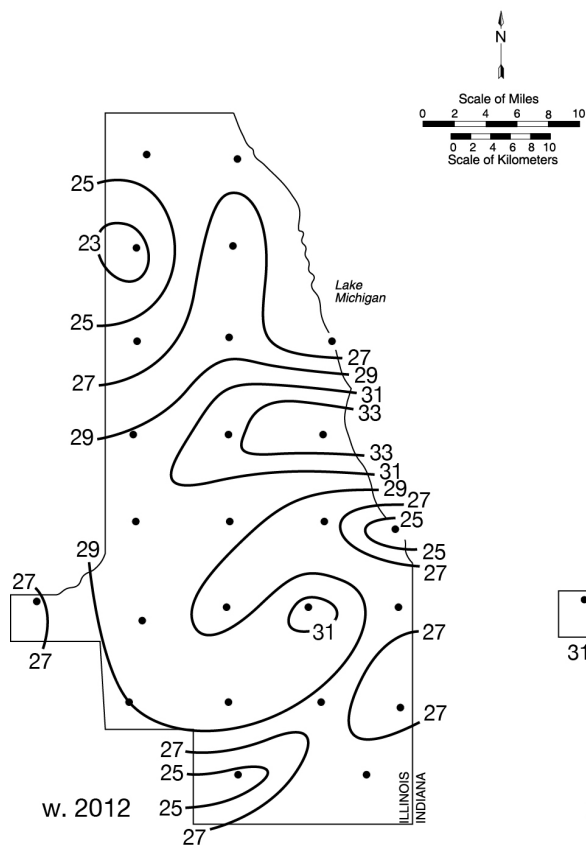
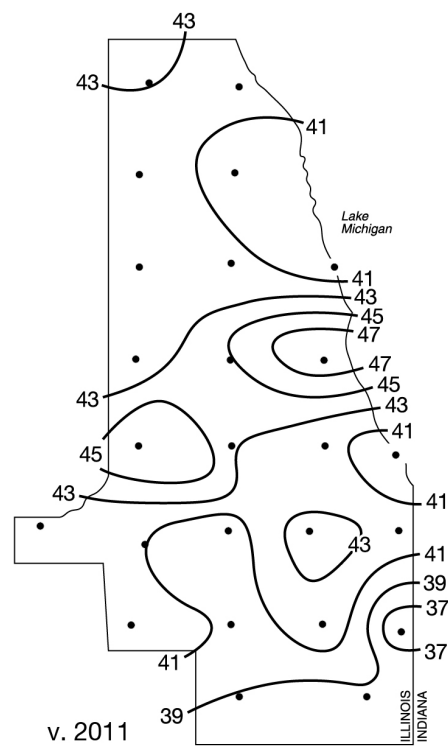
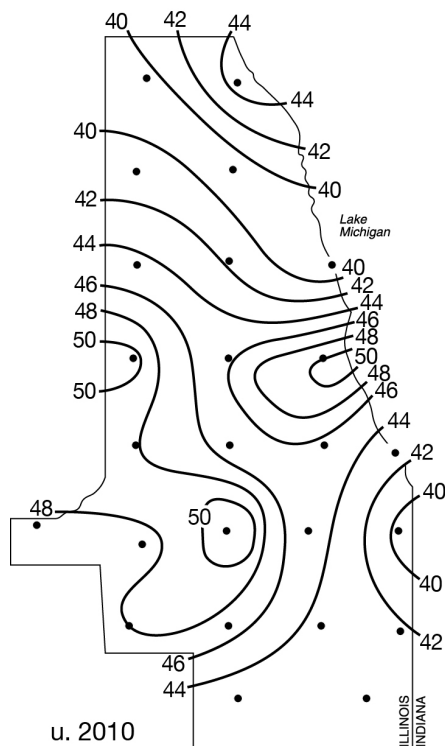


Figure AVII-1(u-x). Continued

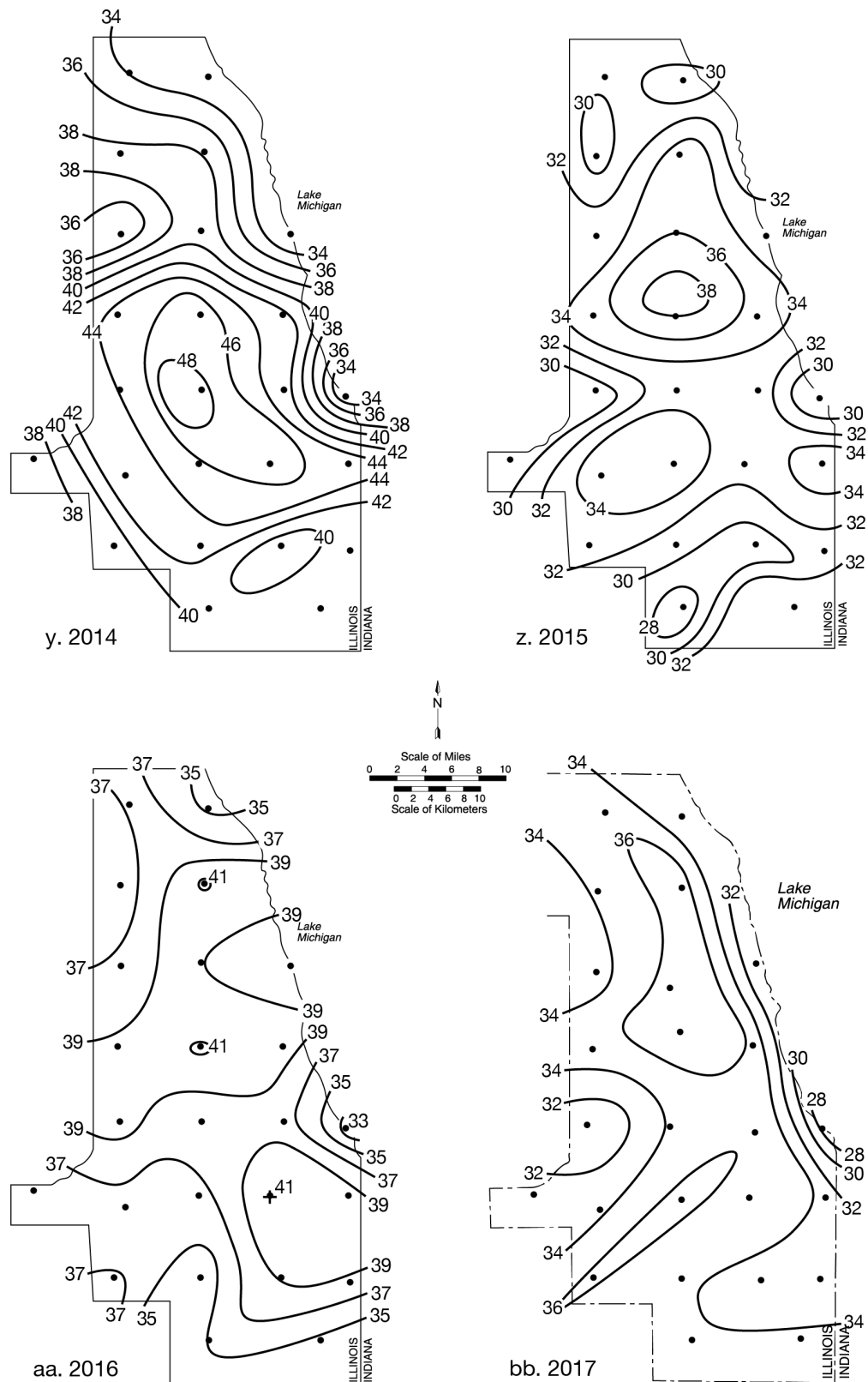


Figure AVII-1(y-bb). Concluded

APPENDIX VIII: DOCUMENTATION OF HIGH STORM TOTALS⁶

This appendix presents the precipitation threshold amounts for 1-year to 100-year recurrence intervals and the aforementioned storm durations for northeastern Illinois in Table VIII-1 (Huff and Angel, 1989).

Table VIII-1. Precipitation Thresholds for 1-year to 100-year Heavy Precipitation Storm Events of Varying Duration

<i>Storm Duration</i>	<i>Precipitation Amounts (inches)</i>						
	<i>1-yr</i>	<i>2-yr</i>	<i>5-yr</i>	<i>10-yr</i>	<i>25-yr</i>	<i>50-yr</i>	<i>100-yr</i>
1 hour	1.18	1.43	1.79	2.10	2.59	3.04	3.56
2 hours	1.48	1.79	2.24	2.64	3.25	3.82	4.47
3 hours	1.60	1.94	2.43	2.86	3.53	4.14	4.85
4 hours	1.69	2.05	2.57	3.02	3.73	4.38	5.13
5 hours	1.79	2.17	2.71	3.19	3.93	4.61	5.40
6 hours	1.88	2.28	2.85	3.35	4.13	4.85	5.68
7 hours	1.93	2.34	2.93	3.44	4.24	4.98	5.83
8 hours	1.98	2.40	3.00	3.53	4.35	5.11	5.98
14 hours	2.22	2.69	3.37	3.96	4.88	5.73	6.72
15 hours	2.24	2.72	3.40	4.00	4.93	5.78	6.78
16 hours	2.26	2.74	3.44	4.04	4.97	5.84	6.84
18 hours	2.30	2.79	3.50	4.11	5.06	5.95	6.97

The isohyetal patterns of the largest four storms that have occurred in Cook County during the past nine years are presented in Figure VIII-1. The network average for the September 12-13, 2008 storm was 6.99 inches with 11 gages in the 50-year and three gages in the 100-year recurrence interval; for the July 23-24, 2010 storm, the network average was 4.52 inches with five gages in the 50-year and three gages in the 100-year recurrence interval; for the July 22-23, 2011 event, the network average was 2.87 inches with one gage in the 50-year and three gages in the 100-year recurrence interval, and finally, for the April 17-18, 2013 storm, the network average was 4.47 inches with one gage in the 50-year recurrence interval.

6: Historical information has been included in this report as required by the sponsor. Appendix VIII content was reproduced from Bauer, 2018 and updated for WY2018.

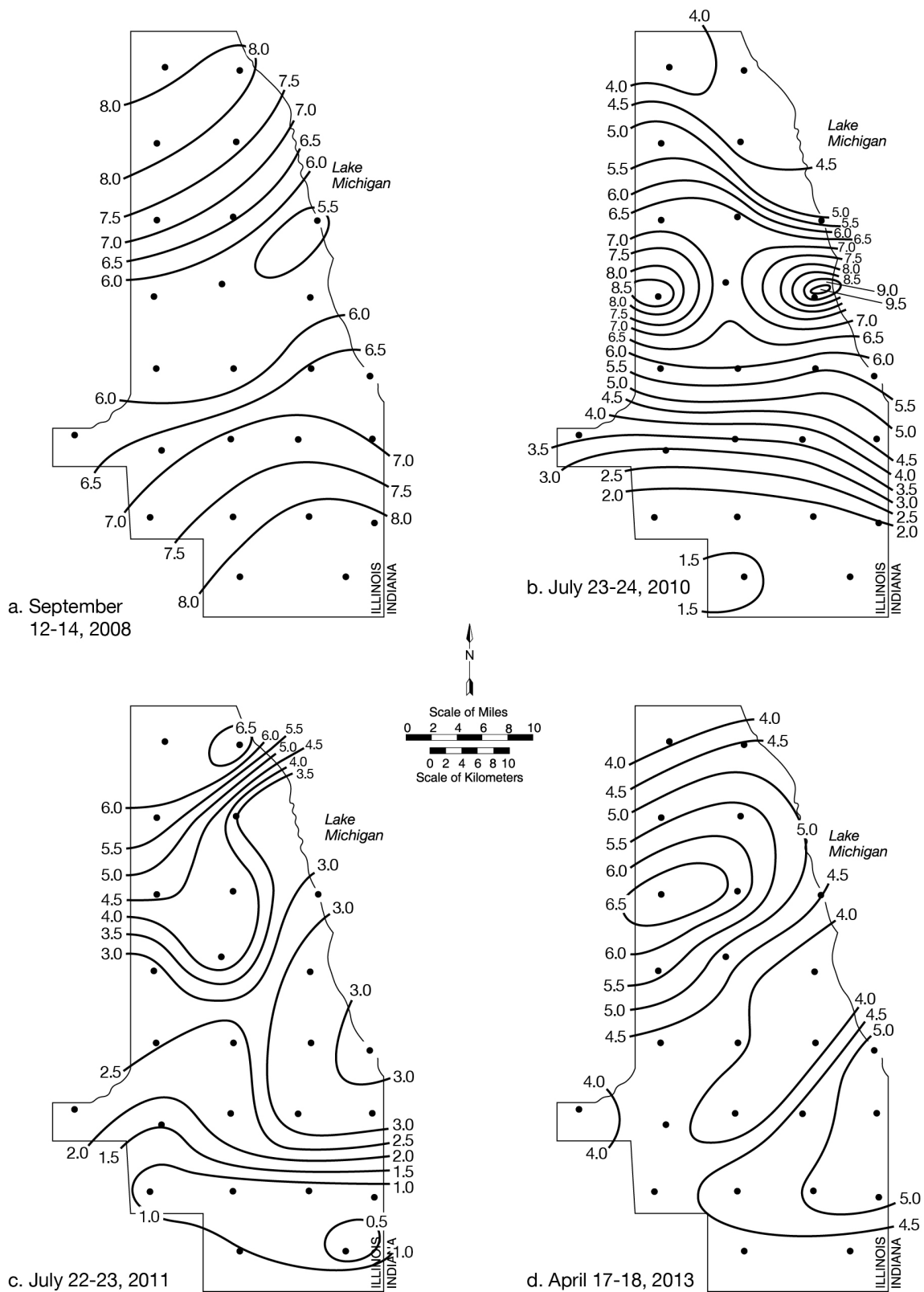


Figure AVIII-1. The four most intense storm events during WYs 2008–2018